VOL. VI PART IV

THE

INDIAN FOREST RECORDS

A Further Note on the Antiseptic Treatment of Timber, recording results obtained from past experiments

BY

R. S. PEARSON, F.L.S., I.F.S.,
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INTRODUCTION.

THE following Record deals with the Antiseptic Experiments carried out in continuation of those, the results of which are given in Volume III, Part II of the *Indian Forest Records.* Chapter IV of that publication outlines the proposals for future investigation, which having been given effect to are described in the following note. When this enquiry was taken up, little or nothing was known in India about the antiseptic treatment of timbers, nor was any plant available in which to treat timber. It was therefore thought advisable to carry out the preliminary experiments by the cheapest and simplest methods possible, and the Open Tank process was adopted. Eight years and more have elapsed since this enquiry was started, and further experience has definitely fixed the value and limitations of the Open Tank process. It has been found suitable for treating posts, poles and sleepers of certain of the softer species of timber, but only in relatively small quantities; thus the outside limit for sleeper treatment by the Open Tank process is put at 50,000 B. G. sleepers per annum.

Though this note deals primarily with experiments carried out by the Open Tank process, in Part V are given the records of a limited number of experiments carried out in pressure plants.

The original scheme according to which the field experiments were to be carried out was drawn up in 1910, and was brought into effect at once, so that the sleepers treated at that time and laid down in 1911 have been six years in the line, while the laboratory experiments were started in January 1909, and have therefore been in progress sufficiently long to give definite results.

Part I reviews the work done up to the time the last note was prepared on the subject; Part II deals with the laboratory experiments; Part III describes the field experiments carried out by treating timber in Open Tanks, according to the prepared scheme; Part IV deals with the field experiments conducted according to the Open Tank process, outside the scope of the scheme; Part V is a record of experiments carried out with the Indian timbers in pressure cylinders; Part VI discusses the factors governing the treatment of timber when carried out under Indian conditions, with special reference to sleeper woods; and Part VII briefly outlines the processes by which timber, other than sleepers, might with advantage be treated in India.

Where reports or other documents have been quoted in the body of the report, the names of the authors, where possible, have been given.

The writer's best thanks are due to Messrs. Billson, Milward, Channer, Lyall and Bailey for help rendered in obtaining sleepers with which to carry out tests and in carrying out experiments in the United Provinces ; to Messrs. Leete, Marsden, Davis and Hefferman, all Burma Foresters, for assistance rendered in connection with supplying and treating sleepers at Pyinmana ; to Mr. Copleston for treating *Terminalia tomentosa* sleepers in the Bombay Presidency ; to Messrs. Thompson and A. L. Chattarjee for help rendered while treating sleepers in the Betul Division of the Central Provinces ; and to Messrs. Perrée, Jacob and Cooper for all the assistance they rendered in connection with the Assam experiments. Also to the Hon'ble Mr. A. B. Hawkins, Manager of the Assam Oil Co., for allowing him to carry out experiments in the Company's Pressure cylinder, which had been especially adapted for the purpose and for much help rendered and kindness shown, without which it would not have been possible to carry out the experiments with Assam species of timber.

On two occasions, Messrs. Rodger and Cox respectively acted for the writer while he was on leave, during which periods the experiments were in their charge, while to Mr. R. S. Troup, a former Forest Economist, is due the credit of the idea of restarting this enquiry, though he was transferred in 1909 before he was able to formulate a complete scheme of investigation.

During the course of the enquiry much valuable assistance has been obtained from Messrs. Howard, F. Weiss and Clyde H. Teesdale, Research Officers of the United States, Forest Service, who most kindly assisted the writer by supplying him with records of the results of their experiments and experience ; while acknowledgments are due to several Railway Engineers, who have, on many occasions, rendered assistance in order to facilitate the inspection of experimental sleepers in the line.

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Treated and Untreated specimens in Laboratory Experimental Ground, Forest Research Institute, Dehra Dun.

[*Frontispiece.*

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PART I.

PREVIOUS RECORDS AND OBJECTS OF THE INVESTIGATION.

1. Record of Previous Work.

A preliminary note dealing with the question of the Antiseptic Treatment of Timber in India was published in 1912, *Indian Forest Records*, Volume III, Part II. This note briefly outlined the past history of the Antiseptic Treatment of Timber in India, suggested Indian timbers suitable for treatment, discussed the various methods of treating timber in vogue at that time, gave the results of laboratory experiments carried out by the Open Tank process, and finally, laid down a scheme according to which it was proposed to carry out further experiments in the field.

The proposals made on pages 105 to 107 of the above-mentioned publication, have been given effect to and as six years have elapsed since the results of the various experiments have been published, it is thought advisable to place them on record without further delay.

2. Primary factors governing the treatment of timber in India.

In practically all parts of the world, the question of treating timber antiseptically has received consideration. In some countries it has already reached the position of a well-established industry, in others the work is in its infancy ; while, in recent years, a great impetus has been

given to the work, due to the increasing necessity for husbanding the world's timber supplies. Wherever the question of treating timber has arisen, certain main principles have had to be followed, though each locality has had to adapt these broad principles to local climatic conditions and to the indigenous species of timber to be treated.

In India, attempts were made as long ago as 1854 to treat indigenous timbers, while further attempts were made to do so in 1878, which led to no definite results. The chief causes of failure are attributed to the reluctance, on the part of the operators, to modify the accepted European principles of treatment to suit Indian conditions.

In most parts of India the climatic variations are extreme, periods of low and extremely high temperature occur, in winter many areas are excessively dry, while during the monsoon moisture is generally in excess. Such conditions rarely exist to the same degree in more temperate zones as, for instance, in Europe and North America, where either treated or untreated timber is never subjected to so trying conditions as it is in India. We have, therefore, factors in India which necessitate certain modifications in the established principles according to which timber should be treated. For instance, the direct effect of the drastic climatic conditions necessitate the greatest care in seasoning our timber, more so indeed than is necessary in countries enjoying a more equable climate. Again, owing to the occurrence of high temperatures, the coal-tar creosotes employed must contain exceptionally high boiling point fractions to obviate excessive evaporation, while the employment of salts is debarred, unless special protective measures are taken to obviate the leaching action due to excessive moisture. Too much importance cannot be attached to these three factors, when considering the possibility of treating timber in India.

3. Object of the investigation.

The primary objects of this investigation were two in number :—firstly, to endeavour to find uses for certain timbers, the demand for which was either less than the supply or non-existent and secondly, to ascertain whether, after treatment with an antiseptic, certain timbers, which come under the class of 'auxiliary species', could be rendered suitable for railway sleepers, and thus minimize the shortage of supplies caused by the ever-increasing demands made by the Indian Railway Companies.

There is another consideration which, though not of direct pecuniary interest, is of vital importance to the Forester. It has been stated elsewhere that in connection with sleepers, the timber-producing species

found in the Indian forests may be divided into " major " and " auxiliary " species. A classification based on similar lines can be evolved in connection with many other industries, such as cabinet work, cooperage, turnery, carriage work, etc., and though, by grouping all such timbers together and calling them " major species ", we obtain a fairly long list of timbers classified under this head, nevertheless the remaining auxiliary species form an infinitely larger group. For sylvicultural, as well as for economic reasons, it is obvious that the removal of mature trees of the auxiliary species should keep pace with the removal of those of greater value, and the only profitable way of doing this is to create a demand for the timbers, one of which, it is fairly certain, will be in the form of treated sleepers.

Persons not acquainted with the conditions of Indian Forestry might, with reason, wish to know why the auxiliary species should be chosen for experiment in connection with the treatment of sleepers, as in Europe and America nearly all species of timber are treated before being laid down as sleepers in the line. The answer is that the forests of India contain at least five species, namely Teak (*Tectona grandis*), Sâl (*Shorea robusta*), Pyinkado (*Xylia dolabriformis*), Deodar (*Cedrus Deodara*) and Nahor (*Mesua ferrea*) which, owing to their durability, require no treatment while, with the exception of Oak, this is not the case elsewhere. These five species of timber, as far as sleeper woods are concerned, are the " major species ", and though Teak is now only used in special cases, such as for bridges, etc., the other four species go to make up the greater percentage of wooden ties supplied by this country. The demand, however, is far in excess of the supply and this necessitates the treatment of the " auxiliary species " to make up the deficit.

The second point referred to concerns the shortage of wooden sleepers in India. Were all other factors to be ruled out of consideration, this factor alone would justify an investigation into the possibility of increasing the supply of sleepers by the treatment of hard-woods of insufficient durability. That difficulty has been experienced by the Railway Authorities in obtaining adequate supplies of sleepers is common knowledge and, as a proof of this assertion, if any is necessary, one has only to refer to the statements showing the imports, during recent years, of Australian and American sleepers into India and to remember that iron ties are commonly found in use on the main lines running far from the sleeper-producing localities.

Another factor has to be taken into consideration in connection with the demand for sleepers, and that is that the Railway Systems of India

are ever expanding and that the rate of construction is likely to increase very considerably after the war, so that not only will large numbers of sleepers be required for new lines, but the annual recurring demand for maintenance will also be increased. Such conditions further demonstrate the great importance of searching for new supplies of sleeper woods in India, the solution to which problem lies, without doubt, in the more extensive utilization of treated sleepers.

Taking the above facts into consideration, it was obviously incumbent on the Forest Department to endeavour not only to find new outlets for its timber but, as the largest timber-supplying agency in the country, to endeavour to put forward practical proposals by which the necessary supplies of sleepers could be obtained by the State and other Railway Companies. The most obvious step was for the Forest Department to turn its attention to those species found in the State Forests, the timber of which was mechanically suitable and which, after careful treatment, could be rendered sufficiently durable to meet the requirements of the Railway Engineers. The next step necessary to ensure success in such an investigation was to determine the available outturn and cost of extraction of suitable timbers, and then to proceed with the necessary experiments. The following chapters deal with the results of the investigations, experiments and conclusions deduced from the enquiry.

PART II.

THE RESULTS OF LABORATORY EXPERIMENTS.

1. Object of the Laboratory Experiments.

Laboratory experiments, of which a full description is given in the previous publication on this subject, were instituted in order (*i*) to obtain a rough idea as to the most suitable antiseptics or groups of antiseptic oils or salts with which to conduct tests in the field, (*ii*) to determine the relative absorption by soft, moderately soft and hard woods when treated in Open Tanks, and the corresponding period of immersion required for each species, (*iii*) to obtain data as to the durability of the treated specimens, and lastly (*iv*) to obtain a rough estimate of the probable cost of treatment. Results obtained from such experiments can only be considered as a stepping-stone to more exhaustive trials and,

though of value, especially to the investigator, should, owing to their limitations, be accepted with caution.

2. Description of the Laboratory Experiments.

The experiments have been carried out on a fairly extensive scale, in so far as the number of antiseptic solutions tested is concerned, no less than 23 different salts and oils, or combination of both having been given a trial. The species of timber selected for trial were twelve in number, comprising all grades from extremely hard to some of the softest timbers of India. The tests carried out being of a strictly comparative nature, so as to keep all factors constant, the same species of timber were employed throughout, the specimens were cut to a uniform size of 18″×2″×2″, and the period of immersion, when possible, was kept constant. It is an established fact that hard-woods absorb less solution than soft-woods during a stated period of immersion so that, to effectually protect a hard species, it is generally necessary to allow a longer period of immersion than would be necessary for a soft-wood species. Again, the amount of absorption permissible is directly proportionate to the cost of the solution employed. These conditions were waived in order to obtain uniform results and to form a correct comparative estimate of the value of the various antiseptics employed. While carrying out the field experiments on a more extensive scale, as described in Part III, full consideration was given to the amount of antiseptic absorbed and to the corresponding cost of treatment of each individual species of timber.

A further precaution taken was to experiment not only with thoroughly seasoned timber, but also to prepare the necessary specimens of each species from the same log. In this way, possible variations in the structure and density of the two specimens of any individual species were avoided, and a true comparison of their relative merits, in a treated and untreated state, rendered possible.

After treatment in the laboratory, a full description of which is given in the former note on the subject, the treated and untreated specimens were put into the ground together, in a place known to be infested by white-ants, and each group inspected periodically. The only exception to the above procedure was in the case of the Powellized specimens, of which no less than 147 treated and untreated pieces were laid down and kept under observation. The only other point requiring mention is that, owing to the number of antiseptic solutions dealt with, all the tests could not be started at one and the same time, while each group had to

be dealt with as the seasoned timber and the antiseptic solutions became available.

3. Results of the Laboratory Experiments.

In the last publication on this subject, it was only possible to give records of durability covering a period of a little over a year. The first group of experiments in connection with the Powellizing process were commenced in April 1909, the next with *Avenarius Carbolineum* oil, *Atlas* solution and *Coal Tar* in June 1909, after which specimens treated with the other antiseptics were laid down up till the end of 1914 : the majority, however, were laid down between 1909 and 1911.

In describing these experiments, the classification adopted has been to place the oils in two groups, according to the time the experiments have been in progress. The salts are dealt with separately in two groups, while the salts and oils combined are dealt with in one group.

It has not been found possible to tabulate the results carried out with the Powellized specimens, together with the other laboratory experiments, as they were started at an earlier date by Mr. Troup, formerly Forest Economist, and were carried out on different lines. They are therefore recorded separately.

The durability results are shown in diagrams, while a précis of results is given in tabulated form.

(*i*) First group of Laboratory Experiments.

Results of Experiments with Powellized specimens.

Diagram I.*

This diagram has been prepared with the object of demonstrating the durability of the treated, as compared with the untreated specimens of each species. The specimens have been under observation from six to seven years, so that sufficient time has elapsed to permit all untreated and some of the treated woods to decay.

To illustrate the results obtained as a whole, the following table has been prepared, which gives the number of treated and untreated specimens originally laid down : those at present in a damaged condition, though still serviceable, and those removed after having been destroyed by white-ants or fungus attack :—

* This will be found in the pocket at the end of this publication.

TABLE I.

Treated.						Untreated.					
Number laid down.	Sound.	Slightly damaged.	Damaged, though serviceable.	Destroyed and removed.	Missing.	Number laid down.	Sound.	Slightly damaged	Damaged, though serviceable.	Destroyed and removed.	Missing.
77	6	17	12	34	8	66	0	2	17	40	7

The outstanding feature of the above results is that, after being 6 to 7 years in the ground, not a single untreated specimen is now absolutely sound, while only 19 are still serviceable, thus clearly indicating the drastic conditions under which the timber was tested.

The treated specimens compare very favourably with those which were not treated; omitting those which were lost while the experiment was in progress, 50 per cent. of those treated as against 32 per cent. of the untreated specimens remain and are still serviceable. Another way of illustrating the results obtained, is to calculate the average life of the treated and untreated specimens, basing the calculation on the time they have been in the ground up to the last date of inspection. By so doing, we find that the average life of the treated pieces up to date is five years and two months and of the untreated pieces, three years and seven months. As time goes on, this difference will increase in favour of the treated timber, as already over 66 per cent. of the untreated, as against under 50 per cent. of the treated specimens, have been removed.

From the above results, it might be argued that Powellizing does not really protect the timber from decay or white-ants, as nearly half the treated specimens have had to be removed within seven years. This would be a correct assumption, were it not for the fact that many of the timbers tested are of an extremely perishable nature such as, for instance, Nos. 3, 6, 10, 26, 44, 45, 46, 47, 51, 65, 69 and 74, which probably nothing but a very heavy absorption of coal-tar creosote would render sufficiently durable to enable them to last seven years.

Another point requiring comment is that of the first 24 treated specimens shown in the diagram, laid down in April 1909, only 7 have failed; of the next 31 specimens, laid down in November 1909, 11 have failed; while of the remaining 22 which were laid down in April 1910, 15 have failed. Such results are not easily explained. Had the first and second batches contained no soft woods, the results would explain themselves, but this was not the case. The only explanation that can be offered is that the method of treatment was not so thorough in the case of the latter batch of specimens, as it was when dealing with the two former, the impregnation having, in every instance, been carried out for the Forest Department by the Powell Process Company.

As a whole the results, so far as the Powell process is concerned, may be regarded as satisfactory, taking into consideration the drastic conditions under which the experiment was carried out.

(*ii*) SECOND GROUP OF LABORATORY EXPERIMENTS.

Experiments carried out with Avenarius Carbolineum *oil*, Coal Tar, Jodelite, Solignum, *Pinus excelsa* Tar *and* Green oil.

This group of experiments have been in progress from six to seven years.

In the case of the *Avenarius Carbolineum, Coal Tar, Solignum* and Pinus excelsa *Tar* specimens, the treatment consisted in painting on the solution hot, a liberal coating being given. In the case of the *Jodelite* and *Green oil* specimens, the treatment was by immersion in hot solutions for 10 to 15 minutes. Details of this work are given in the previous publication.

DIAGRAM II.*

In the accompanying diagram, the results of the experiments are shown so as to illustrate the relative value of the different antiseptics when applied to the different species. To compare the values of the different antiseptics, the following table has been prepared, which gives the number of specimens of each series still remaining sound or sufficiently serviceable not to necessitate their removal, and the average life up to date of the twelve treated and twelve untreated specimens of each group :—

* This will be found in the pocket at the end of this publication.

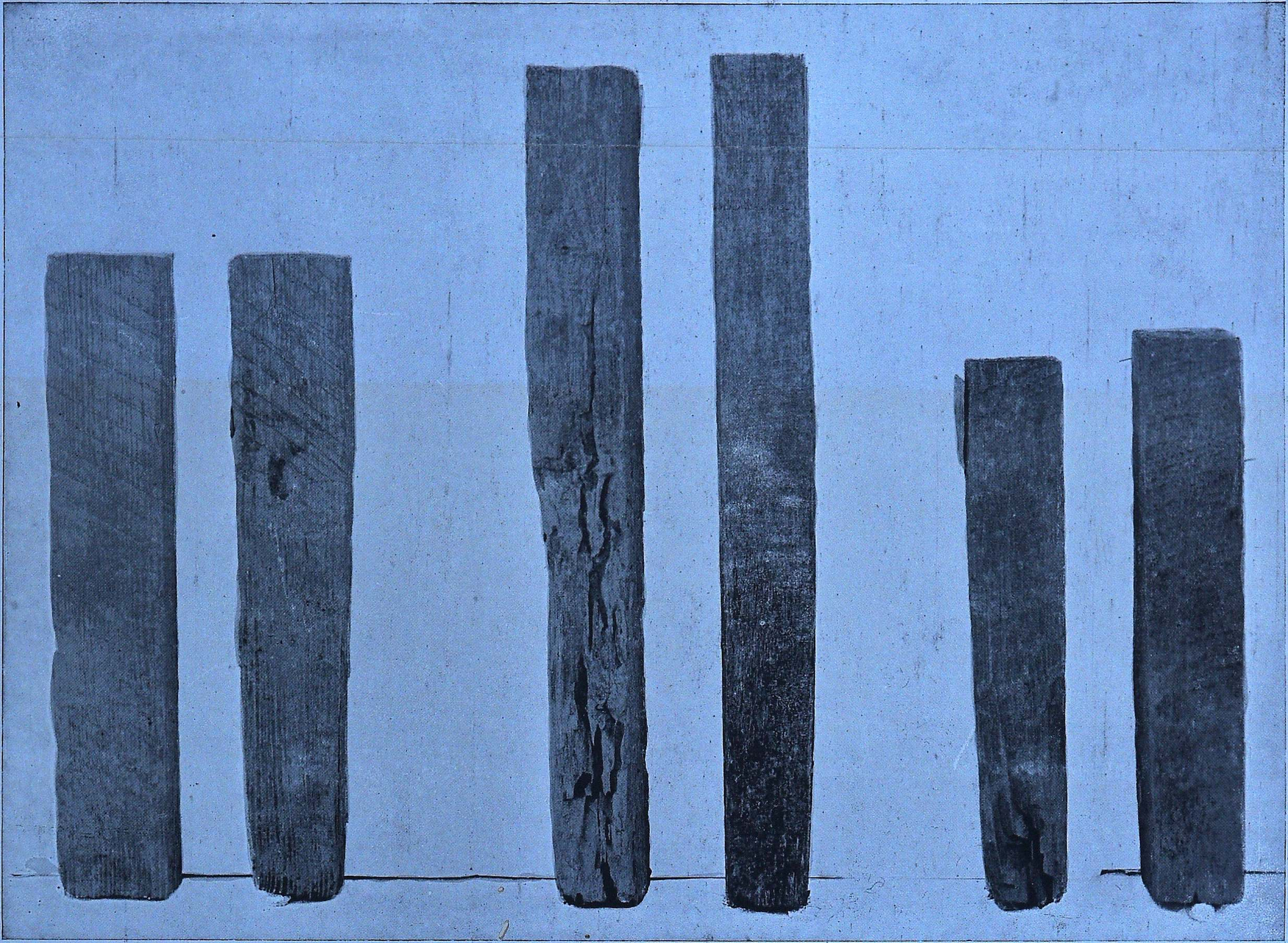

Photo.-Mechl. Dept., Thomason College, Roorkee. Photo by T. B. Chitrakar.

Showing state of specimens after 6 to 7 years. — Left-hand pair, treated specimen is on left side, and the reverse is the case in central and right-hand pairs. — Left hand *Pinus longifolia* treated with Jodelite, central *Pterocarpus macrocarpus* treated with *Green oil*, right hand *Pinus excelsa* treated with Solignum.

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TABLE II.

Antiseptic oil with which the different species of timber were treated.	Treated: Number of years under observation. (Yrs.)	(mos.)	Treated: Number originally laid down.	Treated: Number remaining.	Treated: Average durability, in years. (Yrs.)	(mos.)	Untreated: Number originally laid down.	Untreated: Number remaining.	Untreated: Average durability, in years. (Yrs.)	(mos.)
1. Avenarius Carbolineum.	6	10	12	9*	5	2	12	2*		10
2. Coal Tar . .	6	10	12	2	3	9	12	2	2	10
3. Jodelite . .	6	9	12	7	5	4	12	3	2	8
4. Solignum . .	6	7	12	7	5	7	12	3	3	3
5. *Pinus excelsa* Tar .	6	5	12	3	3	11	12	4	2	11
6. Green oil . .	6	0	12	9	5	8	12	4	2	10

NOTE.—* Out of 9 specimens shown as remaining, five are now missing, while one of the two untreated specimens is also missing, having been lost, probably stolen, after having been under observation for five years and five months.

By referring to diagram II, it will be seen that the most striking results have been obtained by treating soft-wood species; for instance, the *Boswellia serrata* stake treated with *Solignum* has lasted six years and nine months, and is now in a damaged condition but still serviceable, while the excessive damage caused by white-ants and fungus attack rendered the removal of the untreated stake necessary after being in the ground four months. Or again, the *Bombax* stake treated with *Green oil* lasted six years, while the untreated pieces only lasted three months. Similar examples can be given with reference to most of the soft-wood timbers treated with creosote oils.

These experiments were carried out primarily with the object of determining the relative value of these oils, the actual life of any individual treated piece being of secondary importance. It is therefore necessary to examine Table II in detail. Six antiseptics are dealt with, amongst these *Coal Tar*, which was added as a basis for comparison, as its use is universal all over the world and its value recognized. The average life up to date of the specimens treated with *Coal Tar* is three years and nine months, while that of the stakes treated with Tar of *Pinus excelsa* is three years and eleven months, and therefore these two Tars are of about equal value. *Jodelite, Solignum, Avenarius Carbolineum* and *Green oil*, which are *Coal Tar creosote* preparations, all show far better results than *Coal Tar*. Of these *Green oil* stands first, the treated specimens having lasted five years and eight months, out of a possible six years. *Solignum* comes next, the specimens having lasted five years

and seven months, out of a possible six years and seven months; while *Jodelite* has given slightly better results than *Avenarius Carbolineum* oil. There is little to choose between these *Coal-tar creosote* products, all of which have given satisfactory results, when taking into consideration the extremely perishable nature of the timbers used, *viz.*, *Boswellia serrata*, the conifers, *Bombax malabaricum* and *Odina Wodier*.

The relative value of these antiseptics can also be based on the number of stakes in each group still remaining in the ground. It will be seen that the evidence is strongly in favour of the creosote products, as only two stakes treated with *Coal Tar* and three treated with *Pinus excelsa Tar* remain sound, as against nine of each treated with *Avenarius Carbolineum* and *Green oil* and seven of each treated with *Jodelite* and *Solignum*.

Turning again to Table II, it will be seen that the average life of the untreated stakes of each group only varies between two years and eight months and three years and three months—a fact clearly demonstrating the uniformity of the conditions under which the experiments were carried out.

(*iii*) Third group of Laboratory Experiments.

Experiments carried out with Crésoyle, Anthrol, Burma oil, *and* Liquid Fuel *from Borneo.*

These experiments naturally fall into two categories, *i.e.*, those dealing with *Crésoyle* and *Anthrol*, both coal-tar products, which have been in progress five years or more; and those with *Burma oil* and *Liquid Fuel*, both belonging to the petroleum series, the experiments with which have been three and a half years in progress.

The treatment of these groups of specimens varied somewhat, those treated with *Crésoyle* having been immersed for 10 minutes in a cold solution; while those treated with *Anthrol* were immersed in a hot bath for an hour and allowed to remain in the solution as it cooled down, for 16 hours; while the *Burma oil* and *Liquid Fuel* specimens were treated in hot oil for 15 minutes and 45 minutes respectively.

Diagram III.*

Diagram III records the durability of each individual treated and untreated specimen.

Here again, there is a striking contrast between the treated and untreated soft-woods, which is even more marked in the case of the *Creosote oils* than in that of the *Petroleum oils*.

A critical analysis of the relative value of these oils is given in the following Table :—

* This will be found in the pocket at the end of this publication.

TABLE III.

Antiseptics with which the different species of timber were treated.	TREATED. Number of years under observation.	Number originally laid down.	Number remaining.	Average durability, in years.	UNTREATED. Number originally laid down.	Number remaining.	Average durability, in years.
	Yrs. mos.			Yrs. mos.			Yrs. mos.
Crésoyle . . .	5 6	12	9	5 2	12	3	2
Anthrol . . .	5 0	12	12	5 0	12	3	2
Burma oil . .	3 6	12	10	3 4	12	5	2
Liquid Fuel . .	3 6	12	10	3 4	12	3	1

The results obtained so far with *Crésoyle* and *Anthrol* are quite satisfactory: of the specimens treated with the latter, none have failed up to date. The reason for this is due to the method of treatment, as also to the value of the oil. Of the experiments described so far, the treatment has consisted in either soaking the specimens for one hour in hot oil or in immersing the specimens for 10 or 15 minutes in a bath of cold oil. In the case of the specimens treated with *Anthrol*, the treatment was far more drastic, as they were immersed in hot oil for an hour and allowed to remain in the solution for a further period of 16 hours, while it cooled down, resulting in a complete penetration in the case of the soft-wood species and a fairly heavy absorption by the harder timbers. This experiment demonstrates the possibility of preserving even the softest timbers, such as *Boswellia serrata*, *Bombax malabaricum* and *Odina Wodier* for five years and more with a creosote oil.

Turning to the oils with a petroleum base, it will be seen that they, too, protect timber, for though their toxic value is low, their waterproofing properties are considerable, while they render the timber distasteful to white-ants. The experiments with *Burma oil* and *Liquid Fuel* have not as yet been long enough in progress to enable one to form a definite idea as to their value, though it is thought that the results obtained will be less satisfactory than those obtained with *Coal-tar creosotes*. The results with *Burma oil and Liquid Fuel* based on either their average durability or the number of specimens remaining after three and a half years, are exactly equal.

(*iv*) FOURTH GROUP OF LABORATORY EXPERIMENTS.

Experiments carried out with Atlas solution, Béllit, Sodium Fluoride *and* Chloride of Zinc *and* Hylinit.

The experiments dealt with up to this point have all been carried out with oils derived from *Coal-tar* or from a Petroleum base. This

group of experiments deals with salt solutions, such as *Atlas*, a patent solution, which is poisonous; *Béllit*, another patent salt, made up of 80 per cent. *Sodium Fluoride*, 12·5 per cent. *Dinitro-phenol* and 6·5 per cent. *Aniline*; the third salt is composed of 3·5 per cent. Chloride of Zinc, 3·5 per cent. *Sodium Fluoride* and the rest water, while *Hylinit* is a patent solution, the composition of which is unknown though it is stated to be non-poisonous.

The method by which the timber was treated with *Atlas* was to immerse the specimens in a 20 per cent. cold solution for 24 hours. Concentrated *Béllit* was mixed in 44 parts of water and the specimens immersed for 48 hours, the solution having been heated to 120°F. in the initial stages. In the case of *Chloride of Zinc* and *Sodium Fluoride*, a 7 per cent. solution was made up and the timber left to soak for 12 days, while a 10 per cent. solution of *Hylinit* was employed and a 24 hours immersion period given to the specimens.

DIAGRAM IV.*

Diagram IV illustrates the durability of the treated and untreated specimens in each group of experiments.

A glance at this diagram shows that the general durability of the treated specimens is below that of those treated with oil.

To determine the relative value of these salts, Table IV has been prepared :—

TABLE IV.

	TREATED.				UNTREATED.		
Antiseptics with which the different species of timber were treated.	Number of years under observation.	Number originally laid down.	Number remaining.	Average durability, in years.	Number originally laid down.	Number remaining.	Average durability, in years.
	Yrs. mos.			Yrs. mos.			Yrs. mos.
Atlas solution	5 10	12	4*	4 6	12	2†	2 10
Béllit	5 7	12	3	3 4	12	3	2 6
Sodium Fluoride and Chloride of Zinc.	5 7	12	6	4 5	12	2	2 7
Hylinit	5 5	12	4	3 9	12	4	2 11

* This will be found in the pocket at the end of this publication.

† NOTE.—These specimens are now missing, so the experiment has had to be closed.

The most noticeable point in the above table is the relatively few treated specimens remaining after 5 to 6 years, which is attributed not so much to the want of toxic properties in the salts, as to the fact that the salts have been washed and leached out of the timber by excessive moisture. Taking, as an example, the *Atlas* experiment, four out of twelve specimens remain after 5 years and 10 months, of which the timber of two of them is so durable that it is doubtful whether it requires treatment. *Béllit* has given equally poor results, while *Hylinit* is little better than either *Béllit* or *Atlas*.

Of these salts, *Sodium Fluoride* and *Chloride of Zinc* have given the best results which, however, compare unfavourably with the results obtained with the oil solutions. The superiority of *Coal tar creosotes* over salt solutions, in damp climates, is further emphasized by the fact that the timber was treated by applying the oil with a brush or by a short immersion period, as against a long period of immersion often covering several days, in the case of the salt solutions.

(*v*) FIFTH GROUP OF LABORATORY EXPERIMENTS.

Experiments carried out with Anticide, McDaugall's insecticide, Mort-ant *and* Burnettizine.

This group of experiments is virtually a continuation of group IV, it having been separated from that series only in order to facilitate description, and on account of the experiments having been started at a later date than those described above. All four antiseptics dealt with are patents.

The method of treating the timber, in the case of *Anticide*, was to allow it to remain in the cold solution for 64 hours. The specimens treated with *Mort-ant* were given a 15 minutes immersion, those treated with *McDougall's insecticide* a 24 hours immersion in a 4 per cent. solution, while the solution of *Burnettizine* was made up to 40 per cent. strength, heated to 170°F. and the specimens allowed to remain submerged for 64 hours.

The reason for subjecting the timber to different periods of immersion was due to the recommendations of the patentees of the various substances, and to the period of immersion having to be regulated in direct proportion to the cost of the solution. Generally speaking, salt solutions are cheap as compared with coal-tar products, hence the long periods of immersion permissible in the case of experiment coming under groups IV and V.

DIAGRAM V.*

The results obtained with *Anticide, McDougall's insecticide, Mort-ant* and *Burnettizine* are given in Diagram V. They cover a period of from 2 years to 4½ years; the results, therefore, cannot be said to be final.

It will be seen that certain specimens were not laid down in the *Anticide* experiment, which is to be regretted, as it breaks the sequence of these experiments as a whole which, it must be remembered, were instituted primarily to determine the relative value of certain antiseptic solutions, the durability of any individual timber being of secondary importance.

The records given in Diagram V are tabulated below :—

TABLE V.

Antiseptics with which the different species of timber were treated.	TREATED. Number of years under observation.				UNTREATED. Number originally laid down.		
	Number of years under observation.	Number originally laid down.	Number remaining.	Average durability, in years.	Number originally laid down.	Number remaining.	Average durability, in years,
	Yrs. mos.			Yrs. mos.			Yrs. mos.
Anticide . . .	4 6	6	5	4 1	6	0	1 3
McDougall's insecticide	3 8	11	9	3 7	9	2	1 7
Mort-ant . . .	3 9	11	5	2 10	11	5	2 3
Burnettizine . .	2 0	12	8	1 7	12	8	1 8

The results, as will be seen both from the Diagram and Table, are quite satisfactory in the case of *Anticide*, as though one out of six of the specimens has failed, the average life of the six untreated specimens was only one year and three months, while five of the treated specimens have already lasted four and a half years. Nine out of eleven specimens treated with *McDougall's insecticide* remain after three years and eight months, as against two untreated specimens. Taking into consideration that, of the nine treated species remaining, five are for all intents and purposes sound, the results are fairly satisfactory. *Mort-ant* has given less favourable results than either of the two previous solutions; five remain sound out of eleven treated specimens after three years and nine months, while the durability of the treated and untreated specimens is practically the same. The *Burnettizine* experiment has only been in progress two years, so no definite conclusion can be drawn; the fact

* This will be found in the pocket at the end of this publication.

that out of twelve treated specimens four have had to be removed, and that four others are already seriously damaged, does not hold out any great hopes that this solution will prove to be suitable when employed under Indian conditions.

(*vi*) SIXTH GROUP OF LABORATORY EXPERIMENTS.

Experiments carried out with Crésol-Calcium, Aczol *and* Barol.

These antiseptics are combinations of salts and oils, so mixed together as to form emulsions. They are the results of an attempt to overcome certain difficulties in connection with treatment of timber with salts alone. To overcome these difficulties, and at the same time to reduce the cost of treatment, such substances as *Crésol-Calcium, Aczol* and *Barol* have appeared on the market. These preparations aim at combining a salt with an oil and treating the timber with both at the same time; later on, under "Field Experiments," the results of treating timber first with a salt and when dry with an oil will be discussed.

The timber treated with *Crésol-Calcium,* was immersed in a 10 per cent. solution for 7 days. The concentrated solution when mixed with water resembled an emulsion of lime, and gave off powerful phénolic and crésolic fumes. *Aczol* is also a patent solution, probably made up of phénolic substances and copper. To prepare the solution, 2 oz. of *Aczol* were mixed with 20 oz. of *Ammonia Hydrate* and 50 lbs. of water and the specimens allowed to remain in this solution for 24 hours. *Barol* is advertised as a preservative containing oil of great wood-preserving qualities and copper compounds. The timber in this case was immersed in a solution heated to 90°C., for one hour and allowed to remain in the liquid for a further period of 23 hours, while it cooled down.

DIAGRAM VI.*

Diagram VI illustrates the durability of the specimens treated with *Crésol-Calcium, Aczol* and *Barol.*

When studying this diagram, it must be borne in mind that the *Crésol-Calcium* experiment has been in progress five years and five months, and that the *Aczol* and *Barol* experiments have only been in progress between two and two and a half years, hence the want of uniformity of the lines of durability.

The following table summarizes the position of affairs in respect to this group of experiments :—

* This will be found in the pocket at the end of this publication.

TABLE VI.

Antiseptics with which the different species of timber were treated.	TREATED. Number of years under observation.	Number originally laid down.	Number remaining.	Average durability, in years.	UNTREATED. Number originally laid down.	Number remaining.	Average durability, in years.
	Yrs. mos.			Yrs. mos.			Yrs. mos.
Crésol-Calcium . .	5 5	12	4	2 9	12	4	2 11
Aczol . . .	2 5	10	6	2 0	10	5	1 9
Barol . . .	2 3	12*	12	2 3	12	6	1 11

* Of these one has been lost after 2 years and three months.

The results obtained with *Crésol-Calcium* are extremely poor: only four out of twelve treated specimens remain: in fact, the treated specimens have given no better results than the untreated ones. The results of the field experiments with sleepers treated with *Crésol-Calcium* will be dealt with in the next chapter. The results of *Aczol* are equally disappointing; for, though there are still six treated specimens remaining out of ten, this is a poor result considering that the experiment has only been in progress two years and five months. *Barol* so far shows considerable promise, as eleven specimens are not only present but absolutely sound (the twelfth is missing, but as the species in question is Sâl—the most durable of them all—the record may be taken as complete.) It is yet too early to form any definite conclusions as to the value of *Barol*, though it is safe to say that it promises well.

4. Conclusions deduced from the Laboratory Experiments.

As the experiments with various species of *Powellized* timber were started before and were not carried out on the same basis as the other experiments, it is necessary to discuss the results separately. The results obtained are very fairly satisfactory, especially with respect to the first two batches of specimens. The hard and moderately hard woods treated, as compared with the untreated specimens, have fared in proportion better than the treated soft-woods. The reason for this is probably due to the fact that the saccharine and arsenic solution is less liable to be washed out of the hard-wood timber, than is the case with soft-woods. The results of the field experiments with *Powellized* sleepers will be discussed hereafter.

The outstanding feature of the experiments with various *Coal-tar creosote* products, as opposed to salt solutions, is the evidence obtained in favour of the former. It is possible to deduce very striking figures in evidence of this statement by inspecting the

various diagrams. Leaving out of consideration the experiments with crude *Coal-Tar*, *Tar* from *Pinus excelsa*, *Burma oil* and *Liquid Fuel*, diagrams II and III deal with *Coal-tar creosotes*, while diagram IV demonstrates the durability of timbers treated with *salt* solutions. All these experiments have been in progress for five years or more, but we may take the results at exactly five years, so as to bring all results down to a common denominator. The results are as follows :—

TABLE VII.

	Name of antiseptic.	Greatest possible life of all the specimens of each group, added together.	Actual total life of all specimens. Treated.	Actual total life of all specimens. Untreated.	Number of specimens remaining, out of 12 laid down. Treated.	Number of specimens remaining, out of 12 laid down. Untreated
		Years.	Yrs. mos.	Yrs. mos.		
Coal-tar creosote products.	Avenarius Carbolineum.	60	54 9	31 4	8	3
	Jodelite		51 4	26 8	8	3
	Solignum		54 2	32 2	9	4
	Green oil		58 9	31 7	9	4
	Crésoyle		56 9	25 2	11	3
	Anthrol		60 0	24 6	12	3
	TOTAL AVERAGE	60	55 11	28 7	Average 9·5	Average 3·3
	Average per specimen.	5	4 8	2 4·5		
Salts.	Atlas	60	49 2	31 9	5	3
	Béllit		37 0	28 4	4	4
	Sodium Fluoride and Chloride of Zinc.		49 0	28 11	8	4
	Hylinit		42 9	32 6	5	4
	TOTAL AVERAGE	60	44 6	30 4	Average 5·5	Average 3·7
	Average per specimen	5	3 8·5	2 6·3		

The figures speak for themselves : the specimens treated with *Coal-tar creosote* products have lasted on an average four years and eight months and those treated with salts three years and eight and a half months, out of a possible five years. It may, therefore, be stated with safety that *creosote* products are preferable to *salt* solutions for treating timber for use in India. It is just possible that *salt* solutions might answer in the very dry localities, such as in Sind and parts of the Punjab, though that point still remains to be proved.

The value of each oil or salt or combination of salt and oil has been dealt with after recording the result of each individual experiment, so need not be repeated here ; suffice it to say, that the final selection of any given antiseptic which has given satisfactory results, must be decided on its cost and the amount of the substance necessary to preserve the timber for a stated period. These points will come under general discussion in Part VI.

PART III.

RESULTS OF FIELD EXPERIMENTS, TIMBER TREATED BY THE OPEN TANK PROCESS.

1. Object of the Experiments.

The laboratory experiments, the results of which have already been recorded, were carried out with the object of ascertaining the value of certain antiseptics, the durability of any given species after treatment being of secondary consideration. The Field Experiments, on the other hand, were carried out with the primary object of ascertaining the durability of certain timbers after treatment, when used as railway sleepers. Further, by dealing with a fairly large number of sleepers, it was possible to ascertain certain other factors, namely, (*i*) the approximate cost of felling, extraction and conversion of the various species, (*ii*) the approximate cost of treatment with different antiseptics, and (*iii*) to determine the period of immersion required in order to make the sleepers take up the required amount of antiseptic solution.

2. Scope of the Experiments.

(*i*) NUMBER OF SLEEPERS TREATED.

The original scheme, according to which the field experiments were to be carried out, contemplated the treatment of 20,000 sleepers made up of five different species, 1,000 of each to be treated every year, and

each year's treatment to be different. As the work progressed from year to year, the numbers of sleepers treated had to be modified and finally 7,980 sleepers in all were handed over to the State Railways.

(*ii*) SELECTION OF SPECIES.

The first point to be decided upon was the selection of the species of timber with which to carry out the experiments. Some difference of opinion was experienced as to which species should be selected, it being essential that (*i*) the species be available in large quantities, (*ii*) the cost of extraction should not be excessive, (*iii*) the timber be mechanically strong enough to withstand the wear and tear to which it would be subjected, and (*iv*) the timber should lend itself to treatment. It was finally decided to subject five species of timber to trial: namely, those of *Dipterocarpus tuberculatus*, *D. alatus*, *Pinus longifolia*, *P. excelsa* and *Terminalia tomentosa*, and it is with these five species that all the Open Tank experiments have been carried out.

3. Antiseptics used.

In connection with the choice of antiseptics it was necessary to consider, (*i*) which solution would probably render the timber most durable and (*ii*) the cost. When settling the first point, the results obtained from the laboratory experiments were naturally taken into consideration, as also the mass of literature available on the subject from Europe and America. In preference to salt solutions, everything pointed to the use of high boiling-point oils in a country like India, where the temperature during a portion of the year is very high and the moisture during the monsoon period is excessive. Were durability the only factor to be considered, it would not have been necessary to consider experimenting with other antiseptics. Cost, however, claims nearly equal attention, so that it was decided to experiment also with combined salt and oil solutions. Further, as at that time the *Powell* process was being much discussed, it also called for consideration. It was finally decided to experiment with (*i*) the *Powell* process, (*ii*) with *Avenarius Carbolineum* oil, (*iii*) with a mixed impregnation of *Chloride of zinc*, the salt being protected by a coating of *Green oil*, and (*iv*) with a mixture of *Solignum* and *Rangoon oil* or *Liquid Fuel.*

4. Method of Treatment.

The relative merits of the Open Tank treatment as opposed to Pressure plants will be discussed hereafter. In the case of these experiments everything pointed to the use of Open Tanks, for the reason that little

was known at the time about the treatment of Indian timbers; while the scale on which the experiments were to be carried out did not justify the erection of three expensive Pressure plants, one in the Punjab, another in the Central Provinces and a third in Burma. Since then the results of these experiments have proved the possibilities of treated sleepers in India, so that further experiments have been carried out in pressure plants.

5. Brief description of the Antiseptics employed.

(*i*) POWELLIZING.

Powellizing consists in immersing the timber in a *Saccharine* solution containing small quantities of *arsenic*, gradually heated up to a fairly high temperature, the time of immersion depending on the density and size of the timber to be treated. After removal the timber is placed in a drying chamber until it is thoroughly dry. It is virtually an *Open Tank* process, as no pressure is applied during treatment. No reliable information was available at the time the experiments were started as to the merits of this process, except somewhat meagre records from Australia and those obtained from laboratory experiments carried out at Dehra Dun. The cost of treatment is relatively high, though not prohibitive.

(*ii*) AVENARIUS CARBOLINEUM.

Avenarius Carbolineum oil is a *Coal-tar creosote*, some of the constituents of which have high boiling points. It was produced in France and Germany, where its use has been demonstrated for treatment in *Open Tanks*. It has given satisfactory results in the laboratory experiments, while the results obtained with this oil by Professor Henry of the National Forest School at Nancy, are most encouraging. It could only be procured in India before the war at the high price of 2 rupees per gallon, which precludes more than 5 lbs. to 7 lbs. of the oil being introduced into a B. G. sleeper. It remains to be seen whether this very limited amount of oil is sufficient to preserve the timber from decay for a reasonable time: the laboratory results certainly indicate that this is the case.

(*iii*) CHLORIDE OF ZINC AND GREEN OIL.

Treating timber by a mixed impregnation method is a somewhat speculative experiment. Its chief aim is to reduce the cost of treatment. *Chloride of Zinc* alone is a well-known antiseptic in connection with the treatment of timber, the use of which has been discussed in the previous

note on this subject. It has been in use on the Continent and in parts of America for upwards of 50 years, but its drawback is that it leaches out of the timber and, if used in strong solutions, attacks the metals; its great merit is that it is cheap. *Green oil* is a commercial name for a good grade of *Coal-tar creosote*, with high boiling points and a relatively low percentage of tar acids. Its cost in England is $4\frac{1}{2}d.$ per gallon, naked, while it costs about 13 annas per gallon to land it anywhere in the centre of the Indian Peninsula. The treatment with two such solutions consists in first allowing the timber to absorb as much of the salt solution as possible, and then after the sleepers have dried thoroughly, in plunging them in the hot oil bath and permitting them to absorb a relatively small quantity of oil. This has the effect of forming a thin shell of oil-impregnated tissue on the outside, enclosing and preventing the salt from being washed out by moisture and at the same time preventing the foot-rail from coming into direct contact with the salt. The process is cheap when compared with a moderately heavy impregnation of creosote oil only; for, though the salt solution is allowed to penetrate to the centre of the timber it only costs 2 annas 6 pies to treat a B. G. sleeper, while the amount of oil the sleeper is allowed to absorb is only about 25 per cent. of the quantity necessary when treating with oil alone.

(*iv*) SOLIGNUM AND RANGOON OIL

The reason for selecting *Solignum* for trial was that records of its use in India for protecting timber, other than Railway sleepers, are decidedly encouraging, even when only small quantities of oil have been used. *Solignum* is, however, an expensive oil. With a view, therefore, of reducing the total cost and allowing more complete impregnation, it was decided to mix it with equal quantities of *Rangoon oil*, which is relatively cheap.

6. Powellizing Experiments carried out in the Field.

(*i*) ARRANGEMENTS MADE TO CARRY OUT THE EXPERIMENTS AND THE NUMBER OF SLEEPERS TREATED.

The arrangements made to carry out these experiments were that the Forest Department should supply the sleepers f.o.r., that the Railway Board should pay the cost of freight to and from the impregnating plant in Bombay and that the Powell Company should treat 1,000 sleepers free of cost, the cost of impregnating the remainder being borne by the Forest Department.

The number of treated sleepers actually handed over to the Railway Board was as follows :—

TABLE VIII.

Species.	Whence obtained.	Number of treated sleepers actually handed over to Railway Board.
Pinus longifolia	Chakrata Division, United Provinces.	704
„ *excelsa*	Ditto .	809
Dipterocarpus tuberculatus . . .	Pyinmana Division, Burma.	432
„ *alatus*	Ditto .	126
Terminalia tomentosa	West Division, Kanara, Bombay.	860
TOTAL .		2,931

It was originally contemplated that 5,000 sleepers should be treated but, owing to the Powell Company in India closing down, just as the remaining *Dipterocarp* sleepers were on the point of being despatched from Burma, and also in a lesser degree to rejections of faulty sleepers, the experiment had to be considerably curtailed.

(*ii*) COST OF TREATMENT.

It is not possible to form a correct idea of the cost of delivering Powellized sleepers to a Railway Company, based on the experience gained in carrying out these experiments. In the first place, the cost of railing sleepers from Northern India or railing them to Rangoon and then shipping them to Bombay, was excessive. Were it contemplated to supply *Powellized* sleepers to a Railway in India or Burma, the obvious way to do so would be to erect the treating plant in the vicinity of the forest from which the sleepers were to be extracted or near the Railway line. Again, owing to the first batch of *Dipterocarp* sleepers having been converted green and some of the pine sleepers having been prepared from faulty logs, the number of rejections was unduly high and unless the price realized by selling such rejections be deducted from the cost of preparing the total number of sleepers, the figure of cost is incorrect. Experience was, however, gained in carrying out this set of experiments, which resulted in better methods of working being adopted in carrying out the second group of experiments.

In consideration of the above facts, the following calculations are based on the actual number of treated sleepers handed over to the Railway Companies, had they been delivered on rail near the forests from which they were obtained; in other words, leaving out of account freight to and from Bombay.

Royalty charges on the timber are also excluded from these estimates.

Cost of felling, converting, extracting and Powellizing 1,513 *Pinus longifolia* and *P. excelsa* B. G. sleepers :—

	Rs.	A.	P.
Cost of felling and conversion	482	0	0
Cost of extraction to rail	997	0	0
Cost of treatment	1,560	0	0
Miscellaneous charges for handling, branding, etc.	41	0	0
TOTAL	3,080	0	0

Cost of felling, converting, extraction and Powellizing 555 *Dipterocarp* B. G. sleepers :—

	Rs.	A.	P.
Cost of felling	395	0	0
Cost of conversion	388	0	0
Cost of carting to rail	117	0	0
Cost of treatment	573	0	0
Contractors' profits	287	0	0
Miscellaneous charges for handling, branding, etc.	86	0	0
TOTAL	1,846	0	0

Cost of felling, converting, extracting and Powellizing 860 *Terminalia tomentosa* B. G. sleepers :—

	Rs.	A.	P.
Cost of conversion and felling	1,293	0	0
Cost of extraction	587	0	0
Cost of treatment	887	0	0
Miscellaneous charges for handling, branding, etc.	92	0	0
TOTAL	2,859	0	0

The above figures do not represent what was actually spent on these experiments, as they exclude the cost of preparing sleepers which had to be rejected and which were afterwards disposed of at a profit.

The point of primary interest is the cost of putting a treated sleeper on the market. Based on the above figures, the price comes to Rs. 2-0-7 per B. G. Pine sleeper, to Rs. 3-5-3 for B. G. *Dipterocarp* sleepers, and to Rs. 3-5-2 for B. G. *Terminalia tomentosa* sleepers.

No account is taken in the above calculation of either royalty on the timber or on the process. Were these charges included *Pinus excelsa* B. G. sleepers would cost approximately Rs. 5-8-0 and *Pinus longifolia* B. G. sleepers, Rs. 5-0-0 each ; while the two *Dipterocarps* would come to Rs. 4-8-0 per B. G. sleeper and *Terminalia tomentosa* to Rs. 4-11-0 per B. G. sleeper. The reason for the *Pinus excelsa* sleepers costing more than the other species is, that the royalty on the timber is high, the untreated timber finding a ready market in Northern India.

(*iii*) NOTES OF THE BEHAVIOUR OF THE POWELLIZED SLEEPERS, AFTER BEING LAID IN THE LINE.

The above sleepers, after treatment, were handed over to the Railway authorities, and the localities where the sleepers have been laid down, dates of doing so, together with the most recent inspection notes are shown in detail in the accompanying table.

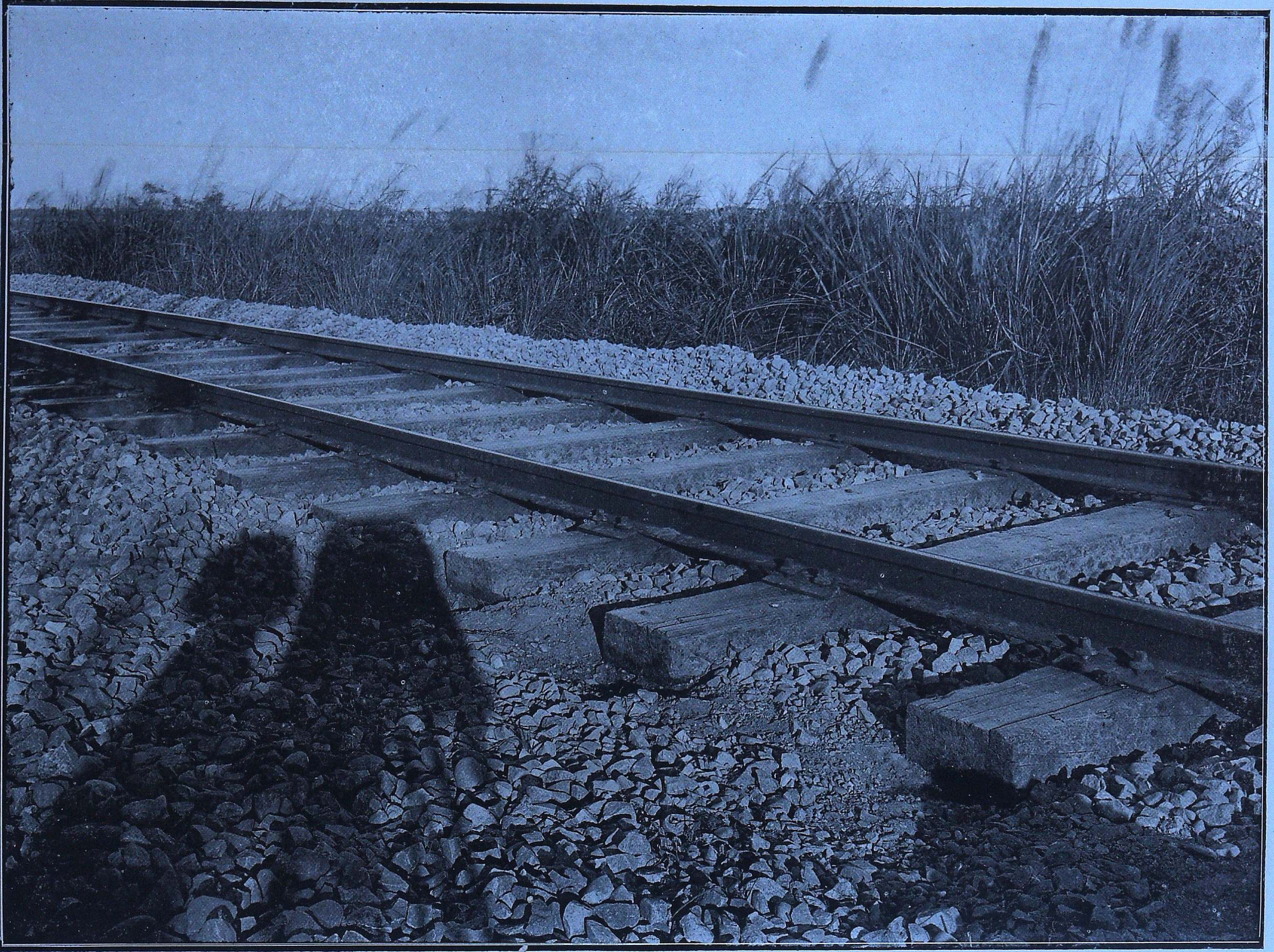

Photo.-Mechl. Dept., Thomason College, Roorkee. Photo by T. B. Chitrakar.

Pinus longifolia Powellized sleepers, after $5\frac{1}{2}$ years in the line. Lhaksar-Hardwar Branch, O. & R. Railway.

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TABLE IX.

Record of Powellized sleepers.

Species.	Number of sleepers laid down.	Locality where laid down.	Date of laying in the line.	Date of last inspection.	Inspection notes	REMARKS.
Pinus longifolia (Chir.)	152 B. G. sleepers.	Hardwar-Lhaksar Section, Oudh and Rohilkhund Railway. Mile 3/17 to 4/1.	15th January 1912.	22nd November 1917.	Thirty-five sleepers are slightly and twelve badly cracked but still serviceable. Two show signs of decay at ends. No sleepers have been removed since last inspection. The sleepers on the whole are in fair order. (Inspected by Executive Engineer and Forest Economist.)	Put in the Road on bearing plates and fixed with screw spikes. Branded P. I. C. / 1—1912.
Ditto	152 B. G. .	Cawnpore-Lucknow branch, Oudh and Rohilkhand Railway. Mile 1/2½ to 1/4¾.	December 1911	November 1917.	Thirteen sleepers split and seventeen are slightly so, while two show signs of decay but serviceable, spikes loose where sleepers have split. They seem to have changed little since last year, and are in fair order. Bearing plates showing a tendency to sink into the timber. The remarks made last year regarding laying the sleepers heart up still apply with equal force. (Inspected by Executive Engineer, and Forest Economist.)	Branded P. L. C. on bearing plates. Three screw spikes per bearing plate.
Ditto	197 B. G. .	Sukkur-Karachi Section, North-Western Railway. Mile 261/14 to 261/77.	5th December 1911.	14th September 1916.	*With bearing plates.*—White-ant attack nil. Indentation of bearing plates into sleepers nil. Holding power of spikes good. General condition good. Those which are somewhat deteriorated are cracked and a few warped. *Without bearing plates.*—Same as above except that rails are cutting into sleepers slightly and dog-spikes on the outer side of rail are crushing the fibre behind them. (Inspected by Mr. H. N. Glass, Assistant Engineer.)	99 with and 98 without bearing plates. Branded P. L. and tin plates.

Record of Powellized sleepers—contd.

Species.	Number of sleepers laid down.	Locality where laid down.	Date of laying in the line.	Date of last inspection.	Inspection notes.	REMARKS.
Pinus longifolia (Chir.)	101 B. G.	Sibi-Quetta Section, North-Western Railway, near Hirok. Mile 206/16 to 206/17.	1st to 10th March 1912.	16th May 1916	(*i*) *Sleepers laid with bearing plates.*—Six sleepers are badly cracked, 18 others shewing signs of cracking which are getting worse. There is little cutting by the bearing plate. The spikes holding well. (*ii*) *Sleepers laid without bearing plates.*—Seven badly cracked, 13 others cracked which will probably develop. Quite 50 per cent. of the sleepers are being cut at rail-seats. Dog-spikes are holding. These are a poor lot of sleepers. (Inspected by the Executive Engineer, Quetta District, North-Western Railway.)	52 with and 49 without bearing plates marked thus 3c-12.
Ditto	210 B. G.	Ranaghat Station, Eastern Bengal State Railway. Mile 46/4 to 46/10.	April 1912	23rd June 1917	These sleepers and those of *Pinus excelsa* are laid in the line mixed; a few sleepers were taken out for inspection, and were found in some cases to be slightly decayed on the under-surface, not sufficiently so to justify rejection in any case. A few show signs of cracking, though taking them as a whole they are in a fair condition. Rail cut not more than before. White-ant attack not increased since last inspection at which time it was slight. (Inspected by Mr. Taylor, Sub-Divisional Officer and Forest Economist.)	Sleepers marked 'C' and re-marked with studded nails.
Pinus excelsa (Kail)	108 B. G.	Hardwar-Lhaksar Section, Oudh and Rohilkhand Railway. Mile 4/1 to 4/2.	7th February 1912.	22nd November 1917.	Two sleepers removed since the sleepers were laid down, none since last inspection. Of these sleepers, 11 are slightly and 5 badly cracked and two show slight signs of decay at ends; they are in good order and generally better than the Chir. (Inspected by Executive Engineer and Forest Economist.)	On bearing plates and fixed with screw spikes. Branded $\frac{\text{P. L.K.}}{\text{1—1912.}}$

Ditto	108 B. G. sleepers.	Cawnpore-Lucknow Branch, Oudh and Rohilkhand Railway. Mile 1/4¾ to 1/6.	December 1911	November 1917.	Fifteen sleepers are split and seventeen slightly so but all are serviccable, except one; the spikes where the sleepers are splitting are not holding very tight. In appearance they are much as they were last year, and show several years' more life. (Inspected by Executive Engineer and Forest Economist.)	Branded P. L. K. 12—11. Laid on bearing plates, and fixed with three screw spikes. Ends not bound.
Ditto	116 B. G.	Sukkur-Karachi Section, North-Western Railway. Mile 261/12 to 261/14.	5th December 1911.	14th September 1916.	*With bearing plates.*—General condition good. White-ant attack nil. Indentation of rail into sleeper marked, considerable in some. Spikes are crushing the fibre at the back. Those which are deteriorated are cracked. *Without bearing plates.*—General condition good. Those which are deteriorated are cracked at ends. (Inspected by Mr. H. N. Glass, Assistant Engineer.)	58 laid with, and 58 without, bearing plates. Branded △ P. E. and tin plates.
Ditto	99 B. G.	Sibi-Quetta Section, North-Western Railway, near Hirok. Mile 206/15 to 206/16.	1st to 10th March 1912.	16th May 1916.	(*i*) *Sleepers laid with bearing plates.*—These sleepers are very much superior to the Chir, *Pinus longifolia*, and on the whole their condition is quite good. None are badly cracked, 3 are cracked through at one end, 8 have minor cracks which are not serious. There is a slight tendency for the bearing plate to cut into the sleepers. Spikes are holding well. (*ii*) *Sleepers laid without bearing plates.*—90 per cent. are being cut into at the rail-cut. One sleeper is badly cracked, 2 are cracked but not getting worse, and six have developed minor cracks which so far are not serious. Spikes holding well. These sleepers are much superior to 'Chir,' *Pinus longifolia*. (Inspected by the Executive Engineer, Quetta District, North-Western Railway.)	49 laid with, and 50 without, bearing plates. Marked thus [K. 3—12]

Record of Powellized sleepers—contd.

Species.	Number of sleepers laid down.	Locality where laid down.	Date of laying in the line.	Date of last inspection.	Inspection notes.	REMARKS.
Pinus excelsa (Kail) .	246 B. G. .	Ranaghat Station, Eastern Bengal State Railway. Mile 46/4 to 46/10.	April 1912	23rd June 1917.	These sleepers and those of *Pinus longifolia* are laid in the line mixed ; a few sleepers were taken out for inspection, and were found in some cases to be slightly decayed on the under-surface, not sufficiently so to justify rejection in any case. A few show signs of cracking, though taking them as a whole they are in a fair condition. Rail-cut not more than before. White-ant attack not increased since last inspection, at which time it was slight. (Inspected by Mr. Taylor, Sub-Divisional Officer and Forest Economist.)	Branded 'K' and to be re-studded with nails.
Dipterocarpus tuberculatus (In.)	434 B. G.	Down line 4,000 feet from the centre of Naihati platform. Mile 22/11 to 22/20. Eastern Bengal State Railway.	6th October 1911.	Ditto	None have been removed to date. Their condition is much the same as when they were laid in the line, the cracking is remarkably slight. They may be said to be doing very well. Screw spike hole not enlarged though rail cut is up to one-eighth inch. (Inspected by Mr. Taylor, Sub-Divisional Officer and Forest Economist.)	Marked serially 1 to 438 of which No. 320, 327, 346, and 427 were originally missing. Branded "DT."
Dipterocarpus alatus (Kanyin.)	121 B. G.	Ditto	Ditto	Ditto .	None have been removed to date. See report on *Dipterocarpus tuberculatus* sleepers. These are exactly in the same condition though showing slightly more tendency to crack. (Inspected by Mr. Taylor, Sub-Divisional Officer and Forest Economist.)	Marked serially 439 to 560, of which No. 510 is missing. Branded "DA."
Terminalia tomentosa (Sain.)	131 B. G. .	Hardwar-Lhaksar Section, Oudh and Rohilkhand Railway. Mile 3/16 to 3/17.	1st September 1911.	22nd November 1917.	Six sleepers removed since they were laid down in the line, none have been removed since last inspection. The rail-cut is insignificant and there are no signs of white-ant attack. Out of the 131 sleepers, 19 are slightly and 17 badly cracked, and 3 show slight signs of decay. On the whole they are in good condition. (Inspected by Executive Engineer and Forest Economist.)	Without bearing plates. Branded P. L. T. / 9—1911.

Ditto	187 B. G.	Cawnpore-Lucknow Branch, Oudh and Rohilkhand Railway. Mile 1/6 to 1/8½.	September 1911	24th November 1917.	Five badly split but not unserviceable, eight split, and the remainder present much the same appearance as they did last year. Spikes holding well. The sleepers were bound at the ends with wire, which in some cases has proved beneficial. Sleepers generally in good order. (Inspected by Executive Engineer and Forest Economist.)	Laid without bearing plates 2 dog spikes per rail seat. Ends bound with wire. Branded $\frac{\text{T. T.}}{11}$
Ditto	158 B. G.	Sukkur-Karachi Section, North-Western Railway. Mile 261/9 to 261/12.	21st July 1911	14th September 1916.	*Sleepers with bearing plates.*—General condition good. White-ant attack nil. Grip of spikes good. Indentation of bearing plates nil. The sleepers which are somewhat deteriorated are cracked at ends. *Sleepers without bearing plates.*—Same as above. Many of the outer dog-spikes have crushed the fibre at the back. Indentation of rail negligible. (Inspected by Mr. H. N. Glass, Assistant Engineer.)	79 laid with and 79 without bearing plates. Branded. T. T. and tin plates.
Ditto	116 B. G.	Sibi-Quetta Section, North-Western Railway, near Hirok. Mile 206/17 to 206/18.	1st to 15th August 1911.	16th May 1916	(*i*) *58 sleepers laid with bearing plates*—Condition generally fairly good. Three badly cracked, 5 cracked and tending to become worse, 15 with shakes, but tending to open out particularly at dog-spikes. No evidence of cutting by bearing plates. Spikes holding. (*ii*) *58 sleepers laid without bearing plates.*—Condition good. None badly cracked, 7 cracked and tending to get worse, and 4 containing shakes, with a special tendency to develop near the dog-spike. There is a slight tendency for the rail-seat to cut into the sleepers. The spikes are holding. This lot of sleepers is superior to No. (*i*). (Inspected by Executive Engineer, Quetta District, North-Western Railway.)	58 laid with and 58 without bearing plates. Marked thus $\boxed{\frac{\text{T. T.}}{8-11}}$
Ditto	122 B. G.	North of Ranaghat, on Down line, mile 46/10 to 46/11. Eastern Bengal State Railway.	1st June 1913	23rd June 1917	None removed to date. As good as the day they were laid in the line. (Inspected by Mr. Taylor, Sub-Divisional Officer and Forest Economist.)	
Ditto	101 B. G.	North of Ranaghat, on Down line, near Chelaram's brick-field. Siding mile 46/11 to 46/12.	22nd June 1913	Ditto	Ditto Ditto.	

(*iv*) NOTE ON THE ABOVE EXPERIMENTS.

Pinus longifolia, 'Chir.'—The sleepers have been in the line from 5 to 6 years and, out of 912 laid down, 5 have been removed during that period. The only report of white-ants attacking the sleepers comes from those laid in the Ranaghat section, Eastern Bengal State Railway, where one sleeper was found to be severely and six slightly damaged. No dry or wet rot has as yet set in so that, as far as the process is concerned, the results to date are very satisfactory, when taking into consideration that this timber barely lasts two years when laid in the line in an untreated state. The reports all mention splitting of the timber, which is in some cases serious. This tendency of the timber to split has probably nothing to do with the treatment, but is an inherent fault of this species of timber. On the other hand, the somewhat unsatisfactory condition of these sleepers has, without doubt, been accentuated by insufficient care having been exercised in selecting them before treatment, and especially by including many sleepers which contained the core of the tree. Again, from results obtained by carrying out these experiments, it has been proved that in the case of this species of timber the sleepers should be laid heart-wood up and sap-wood down, as it is the exposure of the sap-wood to hot sun that increases the tendency of the timber to split; moreover, by laying the heart-wood up a much harder bearing surface is presented to the rail-seat. The tendency of the rail to cut into the timber is not serious, though bearing-plates are necessary. Taking into consideration the class of timber dealt with and the mistakes made in the selection and laying of the sleepers, the results to date may be considered extremely satisfactory.

Pinus excelsa, 'Kail.'—The sleepers have been in the line from 5 to 6 years and out of 677 laid down, two have been removed during that period. There are no reports of white-ants having attacked the sleepers. The tendency of the timber to crack is somewhat less marked than in the case of 'Chir,' though the cut at rail-seat is generally deeper than is the case in that species. The spikes are holding well though, owing to the relative softness of the timber, service plates and screws are absolutely necessary. From results to date, the 'Kail' have shown slightly better results than 'Chir,' due to the greater tendency of the latter species to split. The results to date with *Powellized* 'Kail' are distinctly good, as the life of the untreated timber when used as a sleeper is not longer than that of 'Chir.'

Dipterocarpus tuberculatus, 'In' or 'Eng.'—The sleepers were laid down nearly 6 years ago and up to date none have been removed. Their condition has changed little since being laid in the line; only fine surface

Photo.-Mechl. Dept., Thomason College, Roorkee. Photo by T. B. Chitrakar.

Pinus longifolia Powellized sleepers, after five years in the line. Lucknow-Cawnpore-Branch, O. & R. Ry.

Note.—Left-hand sleeper cut from core of a twisted fibre tree, centre sleeper laid sap-wood up, right-hand sleeper laid heart-wood up, which demonstrates the value of laying Pine sleepers in this way.

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Photo.-Mechl. Dept., Thomason College, Roorkee. Photo by T. B. Chitrakar.

Terminalia tomentosa Powellized sleepers, after five years in the line. Lucknow-Cawnpore Branch, O. & R. Railway.

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cracks have developed, the screw holes have not enlarged, though the cut under the rail-seat is, in some cases, up to ⅛" deep. These *Powellized* 'In' sleepers may be said to be doing very well, when taking into consideration that the life of untreated 'In' sleepers is hardly 5 years. The Sâl (*Shorea robusta*) sleepers laid in the adjoining line at the same time as above, do not present so good an appearance as the 'In' sleepers.

Dipterocarpus alatus, 'Kanyin.'—No sleepers have been removed during the six years they have been in the line. Their condition is very similar to that of the 'In' sleepers, with which they are laid in the same line. The tendency to split in these sleepers is somewhat more marked than in the case of 'In.' The spikes are holding well, while the cut under the rail-seat shows, as it does in the case of the 'In' sleepers, the necessity of using bearing-plates. The results to date of *Powellized* 'Kanyin' sleepers is decidedly satisfactory.

Terminalia tomentosa or 'Asain.'—The sleepers have been in the line nearly 6 years and, out of 814 laid down, 9 have been removed during that period. The removals have been due, in every case, to original faults. It is known that these sleepers were cut from old trees and tops left after logging, hence many of the sleepers show faults. As a matter of fact, this is probably the best of the five species tested for sleepers, as the timber is extremely hard and, though liable to develop cracks, its tendency to do so is not greater than that of 'Pyinkado' (*Xylia dolabriformis*), which is classed as one of the best sleeper woods of India. The spikes hold very firmly, the tendency to cut under the rail-seat is insignificant and no bearing-plates are necessary. The results to date with this species are very satisfactory.

(v) OTHER EXPERIMENTS WITH POWELLIZED SLEEPERS IN BURMA, NOT INCLUDED IN THE ABOVE SCHEME.

A record of considerable value is available from Burma, with respect to 100 sleepers of ten different species of timber which, after having been *Powellized*, were laid down together with an equal number of untreated sleepers of the same species in April 1908, near Pyinmana, on the Rangoon-Mandalay section of the Burma Railways. Their condition is recorded below, the information having been taken from a joint report submitted by Mr. A. Rodger, Forest Research Officer, Burma, and the Assistant Engineer, Yamethin, Burma Railways, after their inspection of the 3rd June 1916.

TABLE X.

Record of Powellized sleepers from Burma.

Species.	Date on which the sleepers were laid down.	Number of sleepers laid down.	Condition of *Powellized* sleepers on the 3rd June 1916.	Condition of untreated sleepers on 3rd June 1916.
Dipterocarpus tuberculatus or 'In' wood.	About March 1908.	10 treated, 10 untreated.	The 6 left in 1915 are still in, all are rather bad, and 3 must be removed at once.	The two remaining sleepers seen in 1915 have been removed rotten and cracked.
Dipterocarpus alatus or 'Kanyin.'	Ditto	Ditto	The 5 remaining sleepers were removed in 1915, as all were cracked and rotten.	All removed by 1913.
Homalium tomentosum	Ditto	Ditto	The 3 remaining sleepers have been removed in 1916, all were cracked and rotten. Experiment closed.	All removed by 1911.
Schleichera trijuga .	Ditto	Ditto	All removed by end of 1914, rotten and spikes not holding.	All removed by 1913.
Terminalia belerica .	Ditto	Ditto	The 2 remaining bad sleepers left last year have been removed in 1916. Experiment closed.	All removed by 1909.
Terminalia tomentosa .	Ditto	Ditto	Six are left not rotten, cracked but serviceable for another year.	All removed by 1915.
Careya arborea . .	September 1907.	9 treated, 11 untreated.	Four still left, fairly good, will last 2 more years.	The remaining 4 were removed in 1915, badly cracked and rotten.
Pinus Khasya . .	Ditto	Ditto	*Three still left, 2 will last for four more months, one must be removed at once, all rotting and splitting.	Four removed in 1908, and 7 removed in 1909. Experiment closed.

* Date of last inspection 18th June 1916.

The sleepers referred to above have been in the line for eight years up to the date of last inspection. Sixty per cent. of the *Dipterocarpus tuberculatus* sleepers have lasted over eight years, three out of ten being left after that period, while the last of the untreated sleepers were removed after being seven years in the line. The *Dipterocarpus alatus* sleepers were all removed within eight years, 50 per cent. of them having lasted that period, while all the untreated sleepers of that species were removed within 5 years. The last of the *Homalium tomentosum Powellized* sleepers were removed after 8 years, the untreated sleepers having lasted 3 years. The *Schleichera trijuga* treated and untreated sleepers both fared badly, lasting 6 years and 5 years respectively. The difference

between the treated and untreated *Terminalia belerica* sleepers is very marked : the former lasted up to 8 years, the latter only one year. The *Terminalia tomentosa* sleepers have done best : six out of ten are still in the line after 8 years, being still serviceable, whereas all the untreated sleepers were rejected within seven years. The *Careya arborea* sleepers have done better than might have been expected : four treated sleepers are still in the line and are in fair condition, whereas all the untreated sleepers were rejected within seven years. The *Pinus Khasya* have done moderately well, three still remaining after 9 years.

In the case of all the above species, the treated compare favourably with the untreated sleepers. From former experiments carried out on an extensive scale with untreated sleepers of *Dipterocarpus tuberculatus* and *D. alatus*, it was ascertained that their life is about 4 years, while that of *Terminalia tomentosa* sleepers is from 5 to 7 years, so that it may be stated definitely that these three species are considerably benefited by *Powellizing*. This is an important point, as all three species are plentiful in Burma.

(*vi*) EXPERIMENTS WITH POWELLIZED SLEEPERS ON THE BOMBAY, BARODA AND CENTRAL INDIA RAILWAY.

An experimental lot of 5000 *Red Sarayah* (probably *Shorea leprosula*) Powellized sleepers were laid down in February 1911, on the Idar-Brahmakhed Extension of the Bombay, Baroda and Central India Railway. The Executive Engineer, Sabarmati, inspected these sleepers in June 1917 and reported as follows :—

" I made an inspection of these sleepers on 18th June 1917—

" *White-ants* :—There had been rain subsequent to the sleepers having been opened out. This tended to remove traces of white-ants. However, I broke open several sleepers that showed signs of attacks from white-ants and am forwarding you 2 typical pieces of these sleepers which, to my mind, prove clearly that, at least after a period of over six years, the process does not cause timber to be immune from attacks of white-ants. You will notice that the wood in process of being destroyed is quite sound and also that the ants have riddled well into the central part of the sleepers. When these sleepers were broken open the white-ants were in evidence in great numbers.

" *Renewals* :—Previous to April 1916 no sleepers were renewed. Since then 300 sleepers have been renewed out of the 4,100 Powellized sleepers put in from mile 55-5 to 57-11. This gives a renewal percentage of 7·3.

" From my inspection I consider that 10 per cent. should now be renewed. Of these sleepers the greater number have become unserviceable owing to cracks and a lesser number owing to the timber having

perished. The tendency of these sleepers to crack, especially when exposed to the sun, has already been noted in previous reports.

"*Fastenings* —I do not find that the fastenings are excessively corroded as compared with those in contact with untreated sleepers."

The record of another experiment with *Powellized* sleepers is available from the Bombay, Baroda and Central India Railway. In July 1911 this railway laid down in the Broach District, a locality notorious for white-ants, the following *Powellized* sleepers for trial :—

9 pieces of *Chloroxylon Swietenia*
5 ,, of *Terminalia tomentosa.*
4 ,, of *Odina Wodier.*
7 ,, of Powtik (Singapore Sarayah).

In August 1915, the Executive Engineer reported that "the sleepers "were all sound, except those marked T. T., which had developed fine "cracks. None of them, however, had been attacked by white-ants." Of the above timbers, the first two would last untreated more than four years, while *Odina Wodier* would certainly not last as long as that in an untreated state. As to the durability of untreated *Sarayah* timber, nothing is known further than that in an untreated state it is not durable when used as sleepers.

(*vii*) GENERAL CONCLUSIONS BASED ON THE RESULTS OF EXPERIMENTS WITH POWELLIZED TIMBER.

To form a correct estimate of the value of the *Powell* process from the results of the above described experiments, it is of importance to differentiate between the rejections due to mechanical defects in the timber and rejections due to deterioration of the fibre or attack by white-ants. In the case of the laboratory experiments, in which the specimens were laid down in three batches, all those which failed of the first two batches were rejected owing to white-ant attack, while some of those of the third batch were rejected due to a combination of dry rot and white-ant attack, and the rest to white-ant attack only. The cause of this is ascribed to faulty treatment due to early inexperience. The reason why white-ants attacked the treated soft-wood specimens is attributed to the fact that the arsenic has, in course of time, been washed out of the timber.

Turning to the field experiments, the results of those carried out according to the Forest Research Institute Scheme have to date given satisfactory results as, with the exception of a few soft-wood sleepers laid down in Burma and on the Eastern Bengal Railway, none have been damaged by white-ants. The only note of warning comes from the

experiments in progress on the Idar-Brahmakhed Extension of the Bombay, Baroda and Central India Railway, where up to 10 per cent. of the *Red Sarayah* sleepers have had recently to be removed, owing to damage by white-ants and to splitting. From the report it appears that the attack is not superficial but that the interior of the sleepers has been attacked. This clearly denotes two facts, *i.e.*, that the treatment still holds good on the surface of the timber and that the antiseptic solution did not penetrate sufficiently deep into the timber. These facts do not necessarily tend to condemn the process but point to the fact that either the treatment was not carried far enough or that *Red Sarayah* does not lend itself readily to treatment unless pressure is applied. The writer is not prepared to accept the sweeping statement made by the inspecting officer that " at least after a period of over six years, the process does not cause timber to be immune from attacks of white-ants," and this for the reason that the Powellized sleepers in many other localities, after nearly the same period, show no signs of white-ant attack.

The next few years should definitely settle the question whether this process is suitable for treating Indian timbers, laid down in the varying climates of this country, while from the results obtained to date it is evident that the process must be combined with more careful methods of seasoning the timber.

In making the above statement, full consideration has been given to the fact that some of the Powellized sleepers laid down in Burma have failed within 8 years and that 10 per cent. of the *Red Sarayah* sleepers have had to be removed due to white-ant attack; on the other hand, the results so far obtained with the *Powellized Pinus longifolia* and *P. excelsa* sleepers, both perishable timbers in an untreated state, are distinctly encouraging.

(7) Field Experiments carried out with *Avenarius Carbolineum* oil.

(*i*) ARRANGEMENTS MADE TO CARRY OUT THE EXPERIMENTS AND THE NUMBER OF SLEEPERS TREATED.

The lines on which this group of experiments were carried out were entirely different from those of the *Powellizing* experiments. In this instance, the whole work was carried out by the Forest Department : the Forest Officers in the various provinces supplying the timber free, while the cost of extraction, conversion and treatment was borne by the Forest Research Institute. The *Terminalia tomentosa* sleepers were treated by Mr. Copleston, Divisional Forest Officer, North Division,

Kanara, the *Dipterocarp* sleepers by Messrs. Leete, Marsden and Hefferman, all Burma Foresters, and the *Pines* by the writer. The sleepers after treatment were handed over to the Railway Authorities, free of cost, as in the case of the *Powellized* sleepers.

The number of treated sleepers actually handed over to the Railways amounted to 326 B.G. *Pinus longifolia*, 400 B.G. *P. excelsa* treated at Jagadhri on the North-Western Railway, 400 M.G. *Dipterocarpus tuberculatus*, and 400 *D. alatus* treated at Pyinmana, on the Burma Railways, and 395 M.G. *Terminalia tomentosa* treated at Tavargatti, on the Madras and Southern Mahratta Railway, in all 1,921 sleepers.

(*ii*) METHOD OF TREATMENT.

(*a*) *Treatment of* Pinus longifolia *and* P. excelsa *broad gauge sleepers.*

The Pine sleepers were treated at Jagadhri by the writer in April 1912, in a 11′ 3″×3′ 9″×2′ 10″ open tank, sunk in a pit nearly flush with the ground. Beneath, a brick flue was constructed, running the whole length of the tank and open at both ends. Over the tank, an 8 feet tripod was erected, to the head of which was fixed a system of pulleys, the lower pulley being fitted with a stout hook. Two pairs of parallel sleepers were placed on each side of the tank and at right angles to it, to receive the sleepers. The sleepers were made up into parcels of six, with strips of iron between each sleeper and the whole bound together with iron slings, fitted with hooks and eyes. On the first parcel being made up, the centre sling was passed over the pulley hook and the load hoisted into the tank. A second parcel was then made up and hoisted on to the top of the first load, effectually submerging it in the oil, the second load being submerged by adding additional sleepers. After immersion for the required period, the weights were removed and the two batches of treated sleepers slung, after the oil had been allowed to drip off, to the opposite side and eventually removed to the stacking yard.

It was found that by allowing a 15 minutes immersion period, 5 minutes for the oil to drip off the sleepers and 15 minutes for stacking and changing them, that 12 sleepers could be treated in 35 minutes.

With a view of ascertaining the period of immersion required in order to make *Pinus longifolia* and *P. excelsa* broad gauge sleepers absorb 3 lbs of oil each, six sleepers of each species were weighed before and

Photo.-Mechl. Dept., Thomason College, Roorkee.

Photo by R. S. Pearson.

Experimental Plant, showing flues and tanks, Pyinmana, Burma.

again after a 10 minutes immersion period. The results are shown below :—

TABLE XI.

	Pinus longifolia.		Pinus excelsa.	
Number of sleepers.	Weight before immersion, in lbs.	Weight after immersion, in lbs.	Weight before immersion, in lbs.	Weight after immersion in lbs.
6	855¾	895¾	683	699

The *Pinus longifolia* sleepers absorbed 40 lbs., and the *Pinus excelsa* sleepers 16 lbs. In order to make each species absorb approximately 3 lbs. each, the period of immersion for *Pinus longifolia* was reduced to 5 minutes and that of *Pinus excelsa* increased to 15 minutes. By treating the two species of Pine timber in this way, 726 *Pinus longifolia* and *P. excelsa* sleepers absorbed 2,789 lbs. or 3·84 lbs. of oil per sleeper. The penetration of the oil into the timber varied according to whether the sleeper contained sap-wood or not, the average depth into the heart-wood of *Pinus longifolia* being ½″ to ¾″ at the ends and half that on the sides while, in the case of *Pinus excelsa*, it rarely exceeded ½″ at the ends and ¼″ on the sides. The temperature of the oil was raised to 80°C. for *Pinus excelsa*, and to 50°C. for *Pinus longifolia* as, at that stage of the experiments, it was thought that any temperature over 50°C. for the latter species would cause the timber to crack. Further experiments have shown that it is possible to raise the temperature to 85°C. or 90°C. without damaging this species of timber.

(*b*) *Treatment of* Dipterocarpus tuberculatus *and* D. alatus *metre-gauge sleepers.*

The Dipterocarp sleepers were treated in 1912 by Mr. Leete, Divisional Forest Officer, Pyinmana, with the help of Mr. Marsden, the Director of the Burma Forest School, and Mr. Hefferman, Extra-Deputy Conservator of Forests. The plant used consisted of 4 small tanks made of galvanized iron sheeting, two of which take 5 and two 6 metre-gauge sleepers at a time. The tanks in which the experiments were carried out are embedded in masonry to within a couple of inches from the top and fitted with brick fire-places and flues running beneath them. They are laid parallel to each other about 8 feet apart, from centre to centre. Along each end of the tanks are two rails, supported on posts about 3 feet

6 inches high, from the ground, on which slides a beam at right angles to the rails and therefore parallel to and above the tanks, filled with flat iron plates. To the centre of the beam are attached two simple wooden pulleys, about 3 feet apart; to raise a parcel of sleepers, two ropes, one over each pulley, are hooked to the chains round the sleepers, and as the parcel of sleepers is raised out of the tank, two small poles or bars are put at right angles across the tank and the parcel allowed to rest on them until it is broken up and the sleepers removed. In the same way the sleepers to be treated are made up into lots over the tank, then bound and lowered into the solution. After having dealt with the sleepers for one tank, the bar is pushed over the next tank and the same operation repeated.

Such a type of plant is very convenient for treating a few sleepers for experimental purposes. With an immersion period of, say, ten hours, the four small tanks can deal with about 48 sleepers a day or 1,200 a month. Were the work to be carried out on a larger scale, it would be necessary to raise the travelling bar to 5 feet above the ground in order to permit of differential, instead of simple pulleys, being used and to have larger tanks of, say, 6 feet 4 inches long by 5 feet broad and 2 feet 8 inches deep, taking two parcels of 9 sleepers each or 18 per tank.

Working with an immersion period of 10 hours and with 10 tanks in use, the number of sleepers which could be dealt with daily would amount to 360, say, 9,000 a month or 100,000 sleepers a year.

The difficulty experienced in sinking the Pine sleepers was not experienced when dealing with the *Dip'erocarp* sleepers, as their specific gravity is higher than that of the Pine woods, so that a bit of old rail was found to be quite sufficient for the purpose.

The treatment of the sleepers was carried out as follows :—

As soon as the oil reached a temperature of about 70°C., the sleepers were put in and allowed to remain in the hot oil at a temperature varying from 75°C. to 90°C. for an hour. At the end of that time the fires were drawn and the sleepers allowed to remain in the oil for another hour while the liquid cooled down. As the work of treating the sleepers was in progress, a number of sleepers were weighed before and after treatment with the result that 72 *Dipterocarpus alatus* and 168 *D. tuberculatus* metre-gauge sleepers absorbed 1·11 lbs. of the oil each. It is probable that this is not a sufficient quantity of oil to protect the timber, so that a longer period of soaking would have been advisable. In order to ascertain the quantity of oil this species of timber will absorb, 4 sleepers were treated for an hour in the hot oil and then allowed to remain in the oil for 19 hours as it cooled down. These sleepers absorbed 9·4 lbs. each or, roughly, 6 lbs. per cubic foot.

(c) *Treatment of* Terminalia tomentosa *metre-gauge sleepers.*

No record is available as to the way in which these sleepers were treated. All that is known is that they were treated with hot *Avenarius Carbolineum* oil under the direction of Mr. Copleston, Divisional Forest Officer, North Division, Kanara, Bombay Presidency.

(*iii*) COST OF TREATMENT.

(*a*) *Cost of treating 326* Pinus longifolia *and 400* P. excelsa *broad gauge sleepers.*

The cost of landing treated sleepers on a railway depends on the locality from which they are obtained, the labour market, the amount of oil absorbed by the timber, its cost, the facilities for handling the sleepers and the cost of the plant. It follows that the cost will vary from locality to locality, so that the figures given below are only applicable to the place at which the experiment was carried out. Royalty charges on the timber are excluded from the calculations, the figures are actuals, except that the cost of slotting, numbering and similar charges, which only occur in experimental work, have been omitted, while 5 per cent. of the cost of the plant has been included.

	RS.	A.	P.
1. Cost of felling and converting 726 *Pinus longifolia* and *P. excelsa* broad gauge sleepers	786	0	0
2. Cost of rafting the above to Jagadhri	86	0	0
3. { Cost of 2,789 lbs. of *Avenarius Carbolineum* oil	403	0	0
3. { Cost of freight on above oil	34	0	0
4. Coolie wages for handling and treating sleepers	45	0	0
5. 5 per cent. on Rs. 331, the cost of tank	17	0	0
6. 5 per cent. on Rs. 100, cost of ropes, pulleys, etc.	5	0	0
7. Miscellaneous charges for fuel, etc.	5	0	0
8. To 10 per cent. loss of oil due to leakage, evaporation, etc.	40	0	0
TOTAL	1,421	0	0

From the above figures it will be seen that the cost of landing a treated broad gauge Pine sleeper on rail, containing 3·84 lbs. of *Avenarius Carbolineum* oil, amounts to Re. 1-15-6, of which the cost of treatment comes to 12 annas per sleeper. *Pinus longifolia* broad gauge sleepers can be purchased at Jagadhri in large numbers for Rs. 3-0-0 each; adding 12 annas for treatment and 4 annas profit for doing so, the cost of delivering treated sleepers on rail, working on a commercial scale, comes to Rs. 4-0-0 per sleeper. Even taking into consideration the high grade quality of *Avenarius Carbolineum* oil, 3·8 lbs. per sleeper is an extremely small amount of oil to effectively protect the timber, so that it would, in

all probabilities, be financially sound to add another 8·2 lbs., or a total of 12 lbs. of oil, and thus raise the price of the treated sleeper to Rs. 5-4-6.

As regards *Pinus excelsa* sleepers, their market value is from Rs. 3-8-0 to Rs. 4-0-0 each at Jagadhri, at which price they find a ready sale, so it follows that to treat this species of timber is hardly profitable.

(b) *Cost of treating 400* Dipterocarpus tuberculatus *and 400* D. alatus *metre-gauge sleepers.*

As has been stated elsewhere, some of the Dipterocarp broad gauge sleepers destined to be Powellized were not utilized for that purpose; they were, therefore, converted into metre-gauge size for this experiment. The number was, however, insufficient; so metre-gauge sleepers were cut direct from the logs to make up the deficit. In the following calculations, the cost throughout has been assumed to be that of cutting direct from the log into metre-gauge size, otherwise the figure arrived at would be entirely misleading.

	Rs.	A.	P.
1. Cost of felling, conversion and extraction of 400 *Dipterocarpus tuberculatus* metre-gauge sleepers .	450	0	0
2. Cost of felling, conversion and extraction of 400 *Dipterocarpus alatus* metre-gauge sleepers . .	400	0	0
3. For spreading, stacking and sorting in Depôt . .	46	0	0
4. Cost of 80 gallons of oil to treat 800 sleepers with 1·11 lbs. of oil	130	0	0
5. Freight on oil	32	0	0
6. Coolies' wages for handling and treating sleepers .	41	0	0
7. 5 per cent. of cost of plant	44	0	0
8. Fuel	89	0	0
9. Miscellaneous charges	13	0	0
10. 10 per cent. less oil lost by evaporation, drip, etc. .	13	0	0
TOTAL .	1,258	0	0

The cost of landing a treated *Dipterocarp* metre-gauge sleeper on rail amounts to Re. 1-9-2, exclusive of royalty on the timber or on treatment, and this with only 1·1 lbs. of the oil to protect the timber. From experience gained since these experiments were carried out, it is considered that 1·1 lbs. of oil is quite inadequate to protect the timber for any length of time; to make the process effective the amount of oil will have to be increased to at least 9 lbs. per metre-gauge sleeper or 6 lbs. per cubic foot. This could not be done with *Avenarius Carbolineum* oil alone, as the cost would be prohibitive. A means of cheapening the oil would have to be found as, for instance, by mixing it with a cheaper solution such as *Burma Earth oil*. How long 1·1 lbs. of the oil will protect the sleepers will be demonstrated by the sleepers so treated and now in the line.

(c) *Cost of treating 400* Terminalia tomentosa *metre-gauge sleepers.*

No detailed figures were kept as to the cost of treating these sleepers, though the total cost for each operation is available :—

	Rs.	A.	P
Felling and extraction	300	0	0
Cost of conversion	400	0	0
Cost of oil	226	0	0
5 per cent. on cost of plant	10	0	0
TOTAL .	936	0	0

The cost of treating a metre-gauge *Terminalia tomentosa* sleeper comes to Rs. 2-5-5, exclusive of royalty on the timber.

(*iv*) NOTES ON THE BEHAVIOUR OF SLEEPERS TREATED WITH *Avenarius Carbolineum* OIL, AFTER HAVING BEEN LAID IN THE LINE.

The sleepers were handed over to and laid down by the Railway Authorities from $2\frac{1}{2}$ to $3\frac{1}{2}$ years ago, so that an insufficient period of time has elapsed to enable definite conclusions being drawn from these experiments. The results are, however, of sufficient interest to justify their being recorded, while by doing so the conditions under which, and localities where, these sleepers have been laid down are placed on record.

TABLE XII.

Record of sleepers treated with Avenarius Carbolineum *oil and laid for experimental purposes in different sections of the line.*

Species.	Number of sleepers laid down.	Locality where laid down.	Date of laying in the line.	Date of last inspection.	Inspection notes.	REMARKS.
		North-Western Railway, Saharanpur District.				
Pinus excelsa (Kail).	400 B. G.	Mile 12/14 to 12/20. Between Muradnagar and Begumabad, 3 miles from latter.	11th July 1913	21st December 1915.	One sleeper badly cracked due to original fault, eleven sleepers developing cracks, rest in good condition. No signs of white-ant attack. (Inspected by Executive Engineer and Forest Economist.)	Marked A. C. KAIL. Numbered 1601 to 2000 on zinc plates.
Pinus longifolia (Chir)	326 B G.	Mile 12/5 to 12/6. Between Muradnagar and Begumabad, 3 miles from latter.	25th July 1913	Ditto	Three sleepers are cracked, due to their having been cut so as to include the heart of the tree. A few show signs of warping which, judging from the adzing to receive the rail, must have occurred before they were laid in the line. They were nearly all laid "heart up," which has given better results than when laid "heart down," as was the case with those laid in the line near Lhaksar. Up to date they compare favourably with the treated *Pinus excelsa* sleepers, of which the record is given above. (Inspected by Executive Engineer and Forest Economist).	Marked A. C. CHIR. Numbered 1201 to 1526, on zinc plates.
Dipterocarpus tuberculatus (In).	134 M. G.	At Pyinmana. Mile 225/7 to 225/8½. Rangoon-Mandalay Main line, Burma Railways.	21st December 1912.	3rd June 1918.	Seven are quite rotten and must be removed. Others fairly good, rather cracked, a few beginning to rot. (Inspected by Mr. A. Rodger and Assistant Engineer, Yamethin.)	Marked 'D T'—A. C. 201-334.

Ditto	133 M. G. .	Between Myitnge and Tagundaing. Mile 378/12½ to 378/14. Upper Burma.	8th December 1912.	30th January 1915.	The following number of sleepers, out of a total of 133, were found to be defective— Slightly cracked . . 6 ,, warped . . 10 ,, cracked and warped 4 Deeply cracked . . 0 Decaying . . . 1 TOTAL . 21 (Inspected by the Deputy Conservator of Forests, Mandalay.)	Marked 'D T.'
Ditto	133 M. G. .	Just south of Maymyo on the Lashio line. Mile 421/12 to 421/15½. Burma Railways.	25th January 1913.	2nd February 1915.	The following number of sleepers, out of a total of 133, were found to be defective— Slightly cracked . . 9 ,, warped . . 7 ,, cracked and warped 4 Deeply cracked . . 6 TOTAL 26 (Inspected by the Deputy Conservator of Forests, Mandalay.)	Marked 'D T.'
Dipterocarpus alatus (Kanyin).	134 M. G. .	At Pyinmana. Mile 225/10 to 225/12½. Rangoon-Mandalay Main line, Burma Railways.	21st December 1912.	3rd June 1916	Seven are quite rotten and must be removed. Others fairly good, rather cracked, a few beginning to rot. None to be removed. (Inspected by Mr. A. Rodger and Assistant Engineer, Yamethin.)	Marked 'D A.'
Ditto	133 M. G. .	Between Myitnge and Tagundaing. Mile 378/10 to 378/11½. Upper Burma.	6th December 1912.	30th January 1915.	Out of 133 sleepers laid down, the following were found to be defective— Slightly cracked . . 15 ,, warped . . 14 Cracked and warped . 6 Deeply cracked . . 1 TOTAL . 36 (Inspected by Deputy Conservator of Forests, Mandalay.)	Marked 'D A.'

Record of sleepers treated with Avenarius Carbolineum *oil and laid for experimental purposes in different sections of the line*—contd.

Species.	Number of sleepers laid down.	Locality where laid down	Date of laying in the line.	Date of last inspection.	Inspection notes.	REMARKS.
Dipterocarpus alatus (Kanyin).	133 M. G.	Just south of Maymyo on Lashio line. Mile 421/15½ to 421/17½, Burma Railways.	25th January 1913.	2nd February 1915.	Out of 133 sleepers laid down, the following were found to be defective— Slightly cracked . . 4 " warped . . 1 Cracked and warped . . 1 Deeply cracked . . 6 TOTAL 12 (Inspected by Deputy Conservator of Forests, Mandalay.)	Marked 'D A.'
Terminalia tomentosa (Sain.)	100	Between Aliganj and Kashipur. Mile 30/7 to 30/8, Rohilkund and Kumaon Railway.	28th June 1913 .	26th January 1917.	The sleepers are serving well but there are 13 per cent. badly and 10 per cent. slightly cracked. (Inspected by the Sub-Divisional officer, Kashipur, Rohilkhund and Kumaon Railway.)	Without bearing plates. Branded A. C. 13.
Ditto	195	Between Bhojeepura Junction and Izatnagar. Mile 193 to 193/4. Rohilkund and Kumaon Railway.	4th August 1913.	26th February 1917.	The sleepers are in good condition and the gauge is keeping well at present. No particular cracks appear to be developing. (Inspected by Assistant Engineer, Bareilly Sub-Division, Rohilkund and Kumaon Railway.)	Ditto
Ditto	100	Between Sitapur and Jharekapur. Mile 55/13 to 55/14. Rohilkund and Kumaon Railway.	8th August 1913.	7th December 1916.	About 9 per cent. of the sleepers are badly cracked and 11 per cent. slightly cracked. All the sleepers are still serviceable. (Inspected by the Assistant Engineer, Sitapur, Rohilkund and Kumaon Railway.)	Ditto

v) GENERAL CONCLUSIONS BASED ON THE RESULTS OF EXPERIMENTS WITH SLEEPERS TREATED WITH *Avenarius Carbolineum* OIL.

It is not possible to judge from the results obtained as to the value of this oil for preserving sleepers, as the oldest experiments have only been in progress 3½ years. The results to date are quite favourable, especially with the Pine sleepers, the timber of which, in an untreated state, is more perishable than that of the *Dipterocarps* and *Terminalia tomentosa.* Whether the small amount of oil put into these sleepers is sufficient to protect them for a reasonable period of time is somewhat doubtful. At the time these experiments were carried out, every attempt was made to keep the cost of treatment as low as possible, though it would probably have been advisable to raise the cost of treatment by allowing a greater absorption of oil or to have reduced the cost of the solution by adding a cheaper grade of oil and thus making it possible to introduce more oil into the timber, without unduly raising the cost of treatment.

In any case, these experiments will be of considerable value, as several of the more recent experiments have been carried out with far larger quantities of good grade creosote oils, which should yield valuable results as to the relative merits of light and heavy impregnation.

8. Field Experiments carried out with *Chloride of Zinc* and either *Green oil* or *Avenarius Carbolineum* and a few sleepers treated with *Atlas* solution and *Green oil*.

(*i*) ARRANGEMENTS MADE TO CARRY OUT THE EXPERIMENTS AND THE NUMBER OF SLEEPERS TREATED.

The arrangements made for treating these sleepers were the same as in the case of the sleepers treated with *Avenarius Carbolineum* oil, with the exception that the *Terminalia tomentosa* sleepers were obtained from the Betul Division of the Berar Circle, Central Provinces, instead of from the Kanara Division in Bombay.

The number of treated sleepers actually handed over to the Railways amounted to 100 *P. longifolia* and 100 *P. excelsa* broad gauge sleepers, treated at Jagadhri, North-Western Railway; 438 *Dipterocarpus tuberculatus* and 437 *D. alatus*, metre-gauge sleepers, treated at Pyinmana, Burma Railways; and 293 *Terminalia tomentosa* broad gauge sleepers, treated at Shahpur, Betul District, Central Provinces. These sleepers, amounting to 1,368 in all, were treated by the writer during the touring season of 1912-13.

The plant used to treat the Pine and *Terminalia tomentosa* sleepers was the same as that used for treating the timber with *Avenarius Carbolineum*, while the *Dipterocarp* sleepers were treated in the Pyinmana plant, details of which are given on page 37.

(*ii*) METHOD OF TREATMENT WITH CHLORIDE OF ZINC AND GREEN OIL.

(*a*) *Treatment of* Pinus longifolia *and* P. excelsa *broad gauge sleepers.*

The Pine sleepers with which this experiment was carried out were all well-seasoned, having been prepared in the hills a full year before treatment. After conversion they were floated down the Tons River to Dhakpathar Depôt, from there brought down the canal to Jagadhri and allowed to season for a further period of 2 or 3 months in the Depôt.

The method of treatment consisted in soaking the sleepers in a 2 per cent. solution of *Chloride of Zinc*, heated to a little over 50°C. for 2 hours, and then allowing them to remain in the solution while it cooled down for a further period of 10 hours. After having allowed the sleepers to dry thoroughly for 10 to 14 days, they were plunged into a hot bath of *Green oil* for 3 to 5 minutes and then removed.

To ascertain the correct period of immersion necessary to make the sleepers take up 15 lbs. of the *Chloride of Zinc* solution, 10 per cent. of the sleepers were given varying periods of immersion, and weighed before and after treatment. Table XIII demonstrates the results obtained :—

TABLE XIII.

Species.	Average absorption per sleeper, of 6 sleepers, in lbs.	Temperature of the *Chloride of Zinc* solution.	Period of immersion.
	lbs.		
Pinus longifolia .	5·5	55°C.	Half hour.
Ditto .	9·8	55°C.	2½ hours.
Ditto .	8·5	60°C.	3 ,,
Ditto .	10·8	71°C.	3 ,,
Ditto .	12·3	67°C	2 hours heating and 10 hours to cool down.
Ditto .	20·0	70°C.	Ditto
	Average 16·1 lbs. absorption after 12 hours immersion.		
	lbs.		
Pinus excelsa .	8	85°C. dropping to 56°C.	Heated for 6 hours and allowed to cool for 6 hours.
Ditto .	20·1	70°C.	Ditto
Ditto .	13·5	70°C.	Ditto
	Average 13·9 lbs. after 12 hours immersion.		

The above figures denote considerable variations in absorption, due chiefly to the amount of sap-wood present in different sleepers and to the differences in density of the timber of individual sleepers. It was found that the average amount of the solution taken up by the *Pinus longifolia* sleepers was 16 lbs. and that of the *Pinus excelsa* sleepers to be 14 lbs. which, together with the oil treatment, is considered sufficient to protect the timber.

The sleepers, after treatment in the salt, were allowed about a fortnight in which to dry, this period being considered sufficient, as at the time of treatment the temperature at Jagadhri stood well over 110°F. in the day, while the hot winds materially hastened the process of drying. The oil bath, to which the sleepers were then subjected, was limited to a 3 to 5 minutes immersion, during which period the *Pinus longifolia* sleepers absorbed 4·4 lbs. and the *Pinus excelsa* 3·5 lbs. of *Green oil* per sleeper. The object of the coating of oil given to the sleepers was primarily to prevent the salt from leaching out of the timber by excessive moisture and also in a measure to preserve the timber.

(*b*) *Treatment of* Dipterocarpus tuberculatus *and* D. alatus *metre-gauge sleepers with* Chloride of Zinc *and* Green oil *and a few with* Atlas *solution and* Green oil.

The *Dipterocarp* metre-gauge sleepers were prepared from logs which had been seasoning for over a year, and were allowed to lie in the depôt for a further period of 2 or 3 months after conversion and before being treated.

The object aimed at in this set of experiments was to treat 700 metre-gauge sleepers with *Chloride of Zinc* and *Green oil* and 300 metre-gauge sleepers with *Atlas* and *Green oil.* The latter process was given a trial, but was abandoned after 30 sleepers had been treated, as it was soon found that working in open tanks, with native labour, the business was too dangerous owing to the high percentage of arsenic in the solution. The balance of the sleepers destined for this experiment were therefore treated with *Chloride of Zinc* and *Green oil.*

A 2 per cent. solution of *Chloride of Zinc* was adopted, and it was decided to try and make the sleepers take up 9 lbs. of the solution, that is, 6 lbs. per cubic foot. The sleepers after treatment in the salt, were allowed to dry thoroughly, a point of great importance and then immersed in *Green oil*

To ascertain the necessary period of immersion in order to make the sleepers take up 9 lbs. of oil each, a number were weighed before, and

after treatment in the *Chloride of Zinc* solution, heated from 60° to 70°C., with the following results :—

TABLE XIV.

Species.	Average absorption, per sleeper, of 5 sleepers.	Temperature of the *Chloride of Zinc* solution	Period of immersion.
	lbs.		
Dipterocarpus tuberculatus.	6·6	70°C.	4 hours in a solution raised to 70°C. and allowed to remain for 20 hours while it cooled down= 24 hours.
Ditto	5·2	Ditto	
Ditto	7·0	Ditto	
Ditto	7·3	Ditto	
Average	6·5 lbs. per sleeper.		
Dipterocarpus alatus	3·4	70°C.	2 hours heating and 6 hours cooling = 8 hours.
Ditto	6·8	Ditto	3 hours heating and 20 hours cooling = 23 hours.
Ditto	6·6	65°C.	2½ hours heating and 19 hours cooling = 21½ hours.
Ditto	7·9	Ditto	3 hours heating and 19 hours cooling = 22 hours.
Ditto	15·2	60°C.	5 hours heating and 15¾ hours cooling =20¾ hours.
Ditto	9·8	60° to 70°C. .	4 hours heating and 20 hours cooling = 24 hours.
Ditto	13·1	Ditto .	Ditto
Ditto	6·2	Ditto .	1 hour heating and 23 hours cooling = 24 hours.
Ditto	8·2	Ditto .	Ditto
Ditto	7·5	Ditto .	Ditto
Ditto	7·8	Ditto .	Ditto
Ditto	6·8	80°C.	1 hour heating and then transferred to another tank of cold oil for 23 hours = 24 hours.

Avera e al sorption per sleeper when immersed for 24 hours= 8·1 lbs.

As in the case of the Pine sleepers, the absorption varied with different batches treated though, on the whole, the amounts taken up were more

uniform than was the case with the conifer timber. The reason for these variations is that no two pieces of timber have the same density or contain the same amount of moisture and resin. The presence of sap-wood is also a powerful factor governing absorption, though in this instance inapplicable, as the sleepers were all cut from heart-wood.

That absorption is directly proportionate to the time of immersion is shown by the 'Kanyin' sleepers, which were immersed for 8 hours and took up 3·4 lbs. each, while those immersed for 24 hours took up an average of 8·1 lbs. Heating the solution also has a striking effect on absorption: twenty-two sleepers were immersed for 24 hours in a cold solution and only took up 3·3 lbs. each, whereas a batch put into a solution raised to 80°C. for 1 hour and then quickly transferred to a cold bath for 23 hours absorbed 6·8 lbs. each. The reason for this is obvious and is the basis on which certain timbers can be treated by the Open Tank method, *i.e.*, that by placing the timber in a hot solution, the air in the timber expands and is driven out and as the wood also expands a small quantity of moisture is also expelled. As the whole cools down, the timber being immersed, instead of again absorbing air, absorbs the solution in which it finds itself. The actual period of heating does not exercise so great an influence on the absorption as the amount of drop in temperature after heating.

After the sleepers had had time to dry thoroughly, they were again immersed—this time in a bath of *Green oil* heated to 50°C. for 5 minutes—during which time each sleeper absorbed 1·1 lb. of oil, thus completing the treatment according to this process.

(c) *Treatment of* Terminalia tomentosa *broad gauge sleepers with* Chloride of Zinc *and* Avenarius Carbolineum *oil.*

The sleepers with which this experiment was carried out were prepared in the Betul District, Berar Circle, Central Provinces, and were treated by the writer in March 1913, in a locally prepared tank, similar to that used at Jagadhri on the North-Western Railway. The 300 broad gauge sleepers to be treated were prepared from trees felled in December 1912 and converted in January and February 1913 and were therefore not thoroughly seasoned. This was unavoidable though to be regretted; while, owing to the fact that this species does not attain a large size in the locality, the sleepers contained a large percentage of sap-wood and were not, taking them altogether, of a very high class. The fact that these sleepers contained sap-wood, is not a drawback, as the sap-wood is hard and, if properly impregnated, is probably as durable as the heart-wood.

The object aimed at was to impregnate the sleepers with from 9 to 12 lbs. of a 2 per cent. solution of *Chloride of Zinc* and to coat them with *Avenarius Carbolineum* oil, having given them time to dry after immersion in the salt solution, the oil treatment being carried out to fix the salt and to preserve the timber.

To ascertain the necessary period of immersion required in order to make the sleepers absorb 12 lbs. of the *Chloride of Zinc* solution, a certain number of sleepers were weighed before and after treatment, with the following results :—

TABLE XV.

Species.	Average absorption, per sleeper, of 15 sleepers.	Temperature of *Chloride of Zinc* solution.	Period of immersion.
	lbs.		
Terminalia tomentosa.	11·4	75°C.	3 hours heating and $18\frac{1}{2}$ hours cooling = $21\frac{1}{2}$ hours.
Ditto	8·5	60°C.	3 hours heating and 21 hours cooling = 24 hours.
Ditto	12·26	79°C.	5 hours heating and 19 hours cooling = 24 hours.
Ditto	13·46	80°C.	Ditto

After having ascertained that it took 5 hours heating to 80°C. and 19 hours cooling, or 24 hours in all, to make the sleepers take up 12 lbs. each, the rest of the sleepers were treated on the same lines.

It was, in a way, gratifying to have found it possible to make so hard a wood as that of *Terminalia tomentosa* take up the required amount in 24 hours, as some difficulty was anticipated in doing so when working with open tanks.

In order to ascertain the time required for the sleepers to regain their natural weight, after having been treated in the salt solution, a number were weighed directly after being withdrawn from the treating tank and again seven days later. The total weight of 15 sleepers was 3,381 lbs. before immersion, 3,551 lbs. after immersion and 3,384 lbs. seven days later. The sleepers had, therefore, practically regained their normal weight within 7 days ; in fact, some were actually lighter than before immersion though, as some were over weight at that time, they were all allowed to dry for a further period of seven days to ensure complete dryness before subjecting them to an oil bath.

The sleepers were then treated in a hot bath of *Avenarius Carbolineum* oil, selected batches of which gave the following results :—

TABLE XVI.

Species.	Average absorption, per sleeper, of 3 sleepers.	Temperature of *Avenarius Carbolineum* oil.	Period of immersion.
	lbs.		
Terminalia tomentosa	2·8	52°C.	10 minutes.
Ditto	3·8	54°C.	8 „
Ditto	2·8	62°C.	5 „
Ditto	3·8	46°C.	5 „
Ditto	2·8	50°C.	3 „
Ditto	3·6	55°C.	2 „
Ditto	2·5	38°C.	Simply dipped in and taken out again.
Ditto	3·3	40°C.	Ditto
Ditto	2·6	40°C.	Ditto

It is clear from the above figures that the result of either dipping in the sleepers and pulling them out again at once or immersing them for upwards of 10 minutes, when dealing with a close-grained timber such as *Terminalia tomentosa*, gives the same results.

This is as might be expected, as the oil in any case could only affect the outer edge of the tissue and fill up the small cracks, not having time to sink deep into the tissue itself. It remains to be seen whether so slight an impregnation of oil will be sufficient to prevent the *Chloride of Zinc* from being leached out of the timber.

Before leaving this group of experiments, it is necessary to record a point of some interest in connection with the rate of absorption of the oil. It was found that, when treating the *Terminalia* and *Dipterocarp* sleepers, the oil was absorbed by the timber much more readily when the sleepers had been originally treated in *Chloride of Zinc* for 24 hours than when no such previous treatment had taken place. The reason for this is no doubt that as the timber had been subjected to a water bath and also a good deal of the sap had been expelled by expansion of the timber due to heating, the surface of the wood and the outer intercellular spaces were clean ; in other words, the outer tissue being porous it was in the best possible state to take up the solution. It follows, therefore, that if difficulty is found in making a dense timber absorb sufficient antiseptic, it should either be immersed in a hot bath or placed in a running stream of water for two or three weeks, and then allowed to dry thoroughly before treatment.

(*iii*) COST OF TREATING SLEEPERS WITH *Chloride of Zinc* AND EITHER *Green oil* OR *Avenarius Carbolineum oil.*

Before considering the cost of treating each different species of timber and in order to clearly define the basis on which the calculations are made, it is necessary to state that the railway freight entered is that which was actually incurred on the whole consignments of both salt and oil, as it has not been found possible to split up the sum in proportion to the amount of antiseptic absorbed by the sleepers and that left over after treatment. In any case the amount was insignificant and would hardly affect the price when worked out to cost per sleeper. The cost of the oil is put at 6 annas 10 pies per gallon, which was the actual price paid; if purchased in bulk the price may be reduced, while the inclusion of the price of oil needed to flood the sleepers can hardly be considered a necessary item of expenditure, and has only been added to form a liberal estimate. And lastly, the labour bills must be considered as excessive, as the coolies were new to the work, while they also include the labour expended on erection of plant. Taking the above points into consideration, the cost of treatment works out as follows :—

(*a*) *Cost of treating 100* Pinus longifolia *and 100* P. excelsa *broad gauge sleepers, with* Chloride of Zinc *and* Green oil.

The Pine sleepers utilized in this experiment were supplied by the Chakrata Division, as were also those used in the *Avenarius Carbolineum* experiments. They were sound, well-seasoned sleepers, containing little twisted fibre though, in some cases, having been cut including the core of the tree. The figures given below do not include either royalty on the timber or on the treatment :—

	Rs.	A.	P.
Cost of felling, conversion and extraction from forests to Jagadhri of 200 broad gauge Pine sleepers	232	0	0
Cost of *Chloride of Zinc* to treat 200 broad gauge sleepers, absorbing 15 lbs. of a 2 per cent. solution at 6 annas per lb. concentrated	22	0	0
Freight on the salt from Calcutta to Jagadhri	12	0	0
Cost of *Green oil* to treat 200 broad gauge sleepers, 4 lbs. per sleeper, at 6 annas 10 pies per gallon	34	0	0
Freight on *Green oil* from Antwerp to Jagadhri, inclusive of oil required to flood them in tank	75	0	0
Labour for treating, stacking, spreading, etc.	38	0	0
5 per cent. of cost of plant	22	0	0
Fuel	4	0	0
10 per cent., due to evaporation and leakage of oil	2	0	0
Miscellaneous charges	8	0	0
TOTAL	449	0	0

The cost of treating a Pine sleeper and delivering it on rail at Jagadhri, therefore, amounts to Rs. 2-3-11, exclusive of cost of timber. Working on a commercial basis, the cost works out as follows :—

Untreated *Pinus longifolia* broad gauge sleepers can be purchased at Jagadhri for Rs. 3-0-0 each. The cost of treating the sleeper comes to Re. 1-1-4; to this must be added royalty on treatment, say, 8 annas, or a total of Rs. 4-9-4 per treated broad gauge "Chir" sleeper. The case of the *Pinus excelsa* sleepers has been dealt with on page 40 and need not be again cited.

(*b*) *Cost of treating 438* Dipterocarpus tuberculatus *and 437* D. alatus *metre-gauge sleepers, with* Chloride of Zinc *and* Green oil.

	Rs.	A.	P.
Cost of felling, conversion and extraction of 875 metre-gauge sleepers at Re. 1-1-0 each	929	11	0
Cost of *Chloride of Zinc* to treat 875 metre-gauge sleepers, absorbing 9 lbs. each of a 2 per cent. solution, at 6 annas per lb., concentrated	59	0	0
Railway freight on the salt (concentrated)	6	0	0
Steamer freight on ditto ditto	5	0	0
Cost of *Green oil* to treat 875 metre-gauge sleepers, absorbing 1·1 lb. each, at 6 annas 10 pies per gallon	41	0	0
Freight on *Green oil* from Antwerp to Rangoon	50	0	0
Railway freight on oil from Rangoon to Pyinmana	18	8	0
Labour for treating and handling	15	8	0
5 per cent. on cost of plant	51	8	0
Cost of fuel	68	0	0
10 per cent., due to evaporation and leakage of oil	11	0	0
Miscellaneous charges	26	0	0
TOTAL	1,281	3	0

The depreciation and fuel charges are, without doubt, high and could be reduced, when working on a more extensive scale. The cost of delivering a metre-gauge *Dipterocarp* sleeper on rail comes to Re. 1-7-5, exclusive of royalty. The Burma Railways pay Re. 1-12-0 for a Pyinkado metre-gauge sleeper, so that to deliver a treated *Dipterocarp* sleeper, the operator would have to be content with 4 annas 7 pies royalty per sleeper, an extremely small profit. He probably gets less than that for his labour when dealing with a Pyinkado sleeper, hence the difficulty experienced in the past by the Railways to obtain all the sleepers they require. Until the price of sleeper woods goes up in Burma, which will probably be the case in the future, the business of treating sleepers in Burma must remain in abeyance.

(c) *Cost of treating 300* Terminalia tomentosa *broad gauge sleepers with* Chloride of Zinc *and* Avenarius Carbolineum.

	Rs.	A.	P.
Cost of felling, conversion, and extraction of 300 broad gauge sleepers	602	0	0
Cost of *Chloride of Zinc* to treat 300 broad gauge sleepers, absorbing 12 lbs. of a 2 per cent. solution, at 6 annas per lb. concentrated.	27	0	0
Railway freight and cart-hire on the salt	6	8	0
Cost of *Avenarius Carbolineum* oil, to treat 300 broad gauge sleepers, absorbing 3 lbs. per sleeper	163	0	0
Cost of railway freight and cart-hire on oil	16	8	0
Labour, for handling, treating and stacking sleepers	50	0	0
5 per cent. on cost of plant	17	8	0
Fuel	13	8	0
10 per cent., due to leakage and evaporation of oil, etc.	16	0	0
TOTAL	912	0	0

The cost per sleeper works out to Rs. 3-0-7. This is a high figure when compared with Pine sleepers treated in a similar way, but using *Green oil* instead of *Avenarius Carbolineum.* The reason is that the former oil costs 6 annas 10 pies, as against Rs. 2-0-0 per gallon; while the cost of extraction was Re. 1-2-6 in the case of Pine sleepers, as against Rs. 2 of *Terminalia tomentosa* sleepers. It remains to be seen whether the use of the more expensive oil is justified by results. *Terminalia tomentosa* may be classed as just below a first class sleeper in an untreated state; if, by treatment, its life can be extended to 12 years or more, it should fetch somewhere about Rs. 4-8-0 to Rs. 4-10-0 on the market. The question of treating it is therefore a commercial proposition, as it costs about Rs. 3-0-0 to exploit and treat a broad gauge sleeper, which should leave a margin of profit for royalty and treatment in the neighbourhood of Re. 1-8-0.

(*iv*) NOTES ON THE BEHAVIOUR OF SLEEPERS TREATED WITH *Chloride of Zinc* AND EITHER *Green oil* OR *Avenarius Carbolineum,* AFTER HAVING BEEN LAID IN THE LINE.

The sleepers have been about 3 years in the line, so no definite results are as yet available. Their condition on the last date of inspection is recorded as below :—

TABLE XVII.

Record of sleepers treated with Chloride of Zinc *and* Green oil *or* Avenarius Carbolineum *and* Atlas *solution and* Green oil *and laid for experimental purposes in different sections of the line.*

Species.	Number of sleepers laid down.	Locality where laid down.	Date of laying in the line.	Date of inspection.	Inspection notes.	Remarks.
Pinus excelsa (Kail.)	100 broad gauge.	North-Western Railway, Saharanpur District. Mile 12/24 to 13/2. Between Muradnagar and Begamabad, 3 miles from latter.	4th August 1913.	21st December 1915.	No sleepers have been rejected up to date. In excellent condition, no signs of cutting under rail-seat, no signs of rot or white-ant attack. Practically all the sleepers laid heart up. (Inspected by Executive Engineer, Saharanpur, and Forest Economist.)	Marked $\frac{\text{C. Z.}}{\text{G. O.}}$ 'Kail.' Treated with *Chloride of Zinc* and *Green oil.*
Pinus longifolia (Chir.)	Do.	Mile 11/24 to 12/1. Between Muradnagar and Begamabad, 3 miles from latter.	3rd August 1913.	Do.	No sleepers have been rejected up to date. In excellent condition, no signs of cutting under rail-seat, no signs of rot or white-ant attack. Practically all the sleepers are laid heart up. (Inspected by Executive Engineer, Saharanpur, and Forest Economist.)	Marked $\frac{\text{C. Z.}}{\text{G. O.}}$ Chir. Treated with *Chloride of Zinc* and *Green oil.*
Terminalia tomentosa (Asain.)	293 broad-gauge.	Mile 516/10¼ to 516/13¼. Great Indian Peninsula Railway, Betul District.	October 1913.	September 1916.	The sleepers are wearing satisfactorily, they are still quite sound and the chairs have not cut into the wood at all. (Inspected by the District Engineer, Jubbulpore).	Marked $\frac{\text{C. Z.}}{\text{A. C.}}$ and $\frac{\text{A. C.}}{\text{C. Z.}}$ Treated with *Chloride of Zinc* and *Avenarius Carbolineum oil.*
Dipterocarpus tuberculatus. (In.)	219 metre-gauge.	Near Pyinmana. Mile 224/13 to 224/15¼. Burma Railways.	23rd July 1913.	3rd June 1916.	Very good on the whole, slightly cracked but not rotten and none to be removed. Spikes holding, rails not eating in. (Inspected by A. Rodger, Esq., Forest Research Officer, Burma, and Assistant Engineer, Yamethin.)	Branded $\frac{\text{D. T.}}{\text{O.}}$ C. Z. Treated with *Chloride of Zinc* and *Green oil.*

TABLE XVII.

Recrod of sleepers treated with Chloride of Zinc *and* Green oil *or* Avenarius Carbolineum *and* Atlas *solution and* Green oil *and laid for experimental purposes in different sections of the line*—continued.

Species.	Number of sleepers laid down.	Locality where laid down.	Date of laying in the line.	Date of inspection.	Inspection notes.	Remarks.
Dipterocarpus alatus (Kanyin.)	218 metre-gauge.	Near Pyinmana. Mile 224/9½ to 224/12. Burma Railways.	19th July 1913 .	3rd June 1916 .	Four are very rotten, attacked by white-ants and must be removed at once. Total found in the line 193; some are cracked and some are beginning to rot, but fairly good on the whole. Spikes holding well, and rails have not cut in badly. (Inspected by A. Rodger, Esq., Forest Research Officer, Burma and Assistant Engineer, Yamethin).	Branded D. A. O C. Z. Treated with *Chloride of Zinc* and *Green oil.*
Ditto .	198 metre-gauge.	Between Myitunge and Taguredaing, Mandalay District. Mile 378/15 to 17.	5th October 1913.	....	....	Branded D. A. C. Z. G. O. Treated with *Chloride of Zinc* and *Green oil.*
Dipterocarpus tuberculatus. (In.)	218 metre-gauge.	Just north of Myingyan, Mandalay District. Mile 352/16 to 18.	25th October 1913.	....	....	Branded D T. C. Z. / G. O. Treated with *Chloride of Zinc* and *Green oil.*

(v) GENERAL CONCLUSIONS BASED ON THE RESULTS OF EXPERIMENTS WITH SLEEPERS TREATED WITH *Chloride of Zinc* AND EITHER *Green oil* OR *Avenarius Carbolineum.*

The primary object of these experiments was to compare the value of a mixed impregnation with the standard method of creosoting, by which some 8 lbs. per cubic foot of a good grade *Coal-tar creosote* are introduced into the timber, otherwise known as the "Fuel Cell" or "Straight method" of impregnation. When comparing the relative merits of the two processes, the most important factors to be considered are (*i*) durability and (*ii*) cost. With respect to these experiments, the durability of the timber cannot be determined for some years, while the cost has been fixed. Broad gauge *Pine* sleepers cost Re. 1-1-4, metre-gauge *Dipterocarp* sleepers cost Re. 0-6-0, and broad gauge *Terminalia tomentosa* sleepers Re. 1-0-0 to treat. *All creosote has to be imported into India, and costs somewhat about 12 annas per gallon, to land at any of the experimental stations; based on this figure, the estimated cost of treating a broad gauge sleeper by the "Full Cell" process is estimated at Rs. 2-4-0, or double the cost incurred when treating broad gauge sleepers by a mixed impregnation process with a salt and oil. Provided the durability tests with sleepers treated by a mixed impregnation method come up to expectation, it may prove to be one of those suitable for treating sleepers under Indian conditions.

9. Field Experiments carried out with Solignum and Burma oil or Liquid Fuel.

(*i*) ARRANGEMENTS MADE TO CARRY OUT THE EXPERIMENTS AND THE NUMBER OF SLEEPERS TREATED.

The fourth and last group of experiments to be carried out, according to the original scheme laid down for this enquiry, consisted in treating the five species of timber selected with a mixture of *Solignum* and *Earth oil*, the former a derivative of *Coal-tar creosote* and the latter of *petroleum* oil. *Solignum* is an expensive oil, though of established value for treating timber; a crude *petroleum* oil was added to it to cheapen the mixture, and thus permit a greater quantity of the solution being introduced into the timber.

The arrangements made to procure the sleepers, and the localities whence they were supplied were the same as those recorded in the previous experiments.

The *Pine* and *Terminalia tomentosa* sleepers were treated by the writer, and the *Dipterocarp* sleepers by Babu Gyan Singh, the writer's assistant.

* NOTE.—Since this was written there is every prospect of Coal-tar Creosote being available in the near future in India.

The number of sleepers handed over to the Railways, after treatment, was 249 broad gauge *Pinus longifolia* sleepers, 100 broad gauge *Pinus excelsa* sleepers, 460 broad gauge *Terminalia tomentosa* sleepers, 470 metre-gauge *Dipterocarpus tuberculatus* sleepers, and 500 metre-gauge *Dipterocarpus alatus* sleepers, in all 1,779 sleepers.

(*ii*) METHOD OF TREATMENT WITH *Solignum* AND *Liquid Fuel.*

(*a*) *Treatment of* Pinus longifolia *and* P. excelsa *broad gauge sleepers and a special batch of* Cedrus Deodara *broad gauge sleepers.*

The aim of this experiment was to treat *Pine* sleepers in a mixture of 40 per cent. *Solignum* and 60 per cent. of *Earth oil.* The amount of oil it was proposed to introduce into each sleeper was 9 lbs., though, owing to some of the sleepers having seasoned in the yard a year longer than others, it was found difficult to keep the absorption constant. This difference was further accentuated by the presence of much sap-wood in some sleepers and little or none in others, necessitating their classification into two separate lots, and subjection to slightly different treatment.

A slight modification was made in the case of these experiments to the usual procedure followed in previous years, by treating 50 *Cedrus Deodara* sleepers, at the special request of the Railway Authorities, these sleepers being supplied free of cost.

In order to fix the immersion period for *Pinus longifolia* sleepers, the following tests were carried out :—

TABLE XVIII.

Species.	Average absorption, per sleeper, of 17 sleepers.	Temperature of *Solignum* and *Liquid Fuel.*	Period of immersion.
Pinus longifolia, 4 weeks out of the floating stream, converted one year before treatment.	lbs. 8·0 6·5 6·8 7·2 8·2 8·5	 80°C. dropping to 55°C. 81°C. „ 60°C. 79°C. „ 68°C. 80°C. „ 63°C. 88°C. „ 66°C. 93°C. „ 73°C.	 6 hours. 4 „ 5 „ 6 „ 6 „ 6 „
Average of 102 broad gauge sleepers.	= 7·5		
Pinus longifolia, 8 to 12 months out of the floating stream, converted two years before treatment.	18·2 27·7 20·2 8·7 10·7 6·8	72°C. „ 56°C. 70°C. „ 60°C. 59°C. „ 57°C. 62°C. „ 50°C. 59°C. „ 50°C. 48°C. „ 48°C.	5 „ 4 „ 2 „ 1½ „ 1½ „ 20 minutes.
Average of 102 broad gauge sleepers.	= 15·4	....	

The remaining sleepers were treated by giving the former class 6 hours', and the latter 1 hour's immersion. It is noticeable that, when allowing the very dry sleepers more than 2 hours in a bath of oil, the amount of oil absorbed is not materially increased, which is no doubt due to the fact that the timber has reached its maximum power of absorption in Open Tanks, a state of affairs known as, "absorption to refusal."

Similar tests were carried out with the *Pinus excelsa* sleepers, which gave the following results :—

TABLE XIX.

Species.	Average absorption, per sleeper, of 17 sleepers in the 1st three lines, and of 8 sleepers in the 4th line.	Temperature of Solignum and Liquid Fuel oil.	Period of immersion.
	lbs.		
Pinus excelsa heart-wood sleepers, 10 to 12 months out of the floating stream, converted 2 years before treatment.	7·5	65°C. dropping to 39°C.	12½ hours.
	9·5	68°C. " 45°C.	12 "
	9·8	74°C. " 46°C.	12 "
	10·0	84°C. " 52°C.	12 "
Average of 59 broad gauge sleepers.	= 9·2		
Pinus excelsa sap-wood sleepers, 10 to 12 months out of the floating stream, converted 2 years before treatment.	8·7	68°C. " 55°C.	6 "
Pinus excelsa, a mixed lot of sap and heart-wood sleepers, 10 to 12 months out of the floating stream, converted 2 years before treatment.	17·7	73°C. " 48°C.	9½ "

By treating heart-wood and sap-wood separately fairly regular results of absorption were obtained, the last batch of mixed heart and sap-wood gave most irregular results, the absorption by the latter being excessive and averaging double that of the former.

Fifty seasoned *Deodar* broad gauge sleepers were subjected to treatment with the following results :—

TABLE XX.

Species.	Average absorption, per sleeper, of two lots of 17 and one lot of 16 sleepers.	Temperature of *Solignum* and *Liquid Fuel* oil.	Period of immersion.
	lbs.		
Cedrus Deodara heart-wood sleepers.	3·6	74°C. dropping to 47°C.	14½ hours.
	6·4	83°C. „ 46°C.	24 „
	9·0	100°C. „ 51°C.	24 „

The results show that *Deodar* timber absorbs oil somewhat less readily than *Pinus longifolia* timber, were it desirable to introduce more than 9 lbs. of oil per broad gauge sleeper into *Deodar*, pressure would have to be resorted to. The experiments with *Deodar* were carried out at the instance of the Railway Engineers, but whether or not it would pay to treat this timber is a moot point, as treatment might increase the durability of the fibre beyond the mechanical life of the timber.

(*b*) *Treatment of* Dipterocarpus tuberculatus *and* D. alatus *metre-gauge sleepers with* Solignum *and* Liquid Fuel, *and a few sleepers with* Liquid Fuel *only*.

These sleepers were treated under the directions of the writer, by Babu Gyan Singh, at Pyinmana, on the Burma Railways. The solution used consisted of two parts *Liquid Fuel* and one part *Solignum*, and the treatment aimed at introducing 5 lbs. of the solution into each metre-gauge sleeper. The actual number of sleepers handed over to the Railways was 500 *Dipterocarpus alatus* and 470 *D. tuberculatus* metre-gauge sleepers treated with mixed *Liquid Fuel* and *Solignum*, and 30 of the latter species impregnated with *Liquid Fuel* oil only.

To ascertain the period of immersion necessary to make the sleepers take up 5 lbs. of oil each, batches of sleepers were weighed before and after immersion, with the following results :—

TABLE XXI.

Species.	Average absorption, per sleeper, of 22 sleepers.	Temperature of the solution.	Period of immersion.
	lbs.		
Dipterocarpus alatus, metre-gauge sleepers.	2·25	75°C. dropping to 63°C. .	2 hours heating and 4 hours cooling=6 hours.
Ditto . .	4·1	75°C. and then allowed to cool down.	2 hours heating and 7 hours cooling=9 hours.
Ditto . .	3·9	Ditto . .	2 hours heating and 7½ hours cooling=9½ hours.
Ditto . .	5·4	Ditto . .	2 hours heating and 11 hours cooling=13 hours.
Ditto . .	5·3	Ditto . .	Ditto.
Ditto . .	4·3	80°C. and then allowed to cool down.	2 hours heating and 8 hours cooling=10 hours.
Ditto . .	4·6	Ditto . .	Ditto
Ditto . .	3·9	Ditto . .	Ditto

Average absorption of all but the 1st lot, which was a trial run, *i.e.*, of 154 sleepers in all=4·6 lbs. per metre-gauge sleeper.

The rest of the sleepers of this species were treated with a 12 hours immersion period. The *Dipterocarpus tuberculatus* sleepers were dealt with in a similar manner with the following results :—

TABLE XXII.

Species.	Average absorption per sleeper, of 22 sleepers.	Temperature of the solution.	Period of immersion.
	lbs.		
Dipterocarpus tuberculatus, metre-gauge sleepers.	3·45	80°C.	2 hours heating and 9 hours cooling=11 hours.
Ditto .	4·1	85°C.	Ditto
Ditto .	4·5	84°C.	2 hours heating and 9½ hours cooling=11½ hours.
Ditto .	4·7	89°C.	2 hours heating and 10 hours cooling=12 hours.
Ditto .	4·4	85°C.	2 hours heating and 12 hours cooling=14 hours.
Ditto .	4·4	Ditto	2 hours heating and 13 hours cooling= 15 hours.
Ditto .	6·25	Ditto	2 hours heating and 14 hours cooling=16 hours.
Ditto .	6·1	Ditto	Ditto
Ditto .	5·0	Ditto	Ditto
Ditto .	4·6	Ditto	Ditto
Ditto .	4·25	Ditto	Ditto
Ditto .	5·4	Ditto	Ditto

Average absorption of 132 sleepers treated under a 16-hours' immersion period=5·29 lbs. per metre-gauge sleeper.

The results of these experiments show that *Dipterocarpus alatus* is easier to treat than *D. tuberculatus*, as 12 hours in the case of the former and 16 hours in the case of the latter, are required to make a metre-gauge sleeper take up about 5 lbs. of oil. On the other hand, the results show variation in absorption by the same species, when treated under precisely the same conditions. This is attributed to the varying percentages of sap-wood and possibly moisture in each batch of sleepers. Another point brought out by these experiments is that on account of the long immersion period necessary to make the sleepers take up even a small quantity of oil, by the Open Tank process, it would probably be cheaper and certainly more expeditious, to treat them under pressure.

(c) *Treatment of* Terminalia tomentosa *broad gauge sleepers, with* Solignum *and* Liquid Fuel *oil.*

The *Terminalia tomentosa* broad gauge sleepers were treated in a mixture consisting of 33 per cent. of *Solignum* and 67 per cent. of *Liquid Fuel* oil, the object aimed at being to introduce 9 to 10 lbs. of the solution into each broad gauge sleeper. The work was started by the writer who, after fixing the immersion period necessary to make the sleepers take up the required quantity of oil, entrusted the work to his assistant, Babu Gyan Singh.

The sleepers were prepared from trees felled during the working season of 1913, in the Betul forests, and were treated in November 1914, having therefore had 16 to 18 months in which to season. An attempt was made to treat these sleepers in February 1914, but as they were at that time insufficiently seasoned, the work was postponed until the following November.

To ascertain the period of immersion necessary in order to make the sleepers take up 9 to 10 lbs. of oil, 25 per cent. of the sleepers were weighed before and after treatment, with the following results :—

TABLE XXIII.

Species.	Average absorption, per sleeper, of 19.	Temperature of the solution.	Period of immersion.
	lbs.		
Terminalia tomentosa, broad gauge sleepers.	10·1	89°C. dropping to 49°C.	3 hours heating and 21 hours cooling=24 hours.
	9·4	90°C. ,, 51°C.	Ditto
	8·95	90°C. ,, 50°C.	Ditto
	10·3	90°C. ,, 53°C.	Ditto
	9·25	90°C. ,, 51°C.	Ditto
	10·6	90°C. ,, 45°C.	Ditto

Average absorption per broad gauge sleeper of 114 sleepers=9·77 lbs.

The most noticeable point in the above figures is the marked regularity in absorption, which is attributed to the sleepers being well-seasoned and containing little sap-wood. The immersion period of 24 hours is a long one, but when the close, hard nature, of the timber is taken into consideration, the quantity of oil absorbed is surprisingly high. The sleepers, after treatment, were handed over to the Great Indian Peninsula Railway authorities and laid in the line.

(*iii*) COST OF TREATING SLEEPERS WITH *Solignum* AND *Liquid Fuel* OIL, MIXED IN VARYING QUANTITIES.

When considering the financial aspect resulting from treating sleepers with *Solignum* and *Liquid Fuel* oil, it must be borne in mind that *Solignum*, though, as before stated, a very high class *coal-tar creosote* preparation, is also very expensive, while *Liquid Fuel* in comparision, is cheap. Results alone can prove whether the use of so costly an oil as *Solignum* is justified.

(*a*) *Cost of treating 350* Pinus longifolia *and 100* P. excelsa *broad gauge sleepers.*

The mixture in which the sleepers were treated consisted of 40 per cent. *Solignum* and 60 per cent. *Liquid Fuel* oil.

	Rs.	A.	P.
Cost of felling, converting and landing 350 broad gauge sleepers at Jagadhri	350	0	0
Cost of *Liquid Fuel* oil at 5 annas per gallon, including freight to Jagadhri, each sleeper absorbing 9 lbs. of oil, of which 3-5th was *Liquid Fuel* oil, to treat 350 broad gauge sleepers	59	1	0
Cost of *Solignum* at Rs. 3 per gallon, each sleeper absorbing 2-5th of 9 lbs. or 3·6 lbs.	378	7	0
Cost of coolie labour, fuel and miscellaneous expenses .	63	0	0
5 per cent. cost of plant	21	0	0
2 per cent. due to evaporation and leakage of oil . .	38	0	0
Total cost of treating 350 broad gauge *Pine* sleepers .	909	8	0
Average cost of treating a broad gauge *Pine* sleeper .	2	9	10

The *Solignum* oil was actually supplied from England, free of charge, by the India Office. In the above calculations its value is placed at Rs. 3-0-0 per gallon, at which price it can be purchased in India. The cost of exploiting the sleepers and landing them on rail at Jagadhri came to Re. 1-0-0 per sleeper, therefore the cost of treatment came to Re. 1-9-10 per broad gauge *Pine* sleeper. Royalty charges are not included in the above calculations; broad gauge *Pinus longifolia* untreated sleepers can be purchased at Jagadhri in large numbers for Rs. 3-0-0, to which must be added 4 annas royalty on treatment and Re. 1-9-10 the cost

of treatment. It follows, that were such an undertaking contemplated on commercial lines, the Railways would have to pay Rs. 4-14-0 per broad gauge *Pinus longifolia* sleeper treated with 9 lbs. of *Solignum* and *Liquid Fuel* oil, mixed in the proportion of 4 to 6.

(*b*) *Cost of treating 470* Dipterocarpus tuberculatus *and 500* D. alatus *metre-gauge sleepers, with a mixture of 33 per cent. of* Solignum *and 66 per cent. of* Liquid Fuel *oil.*

	Rs.	A.	P.
Cost of felling, conversion and extraction of 970 metre-gauge sleepers to Pyinmana	1,212	8	0
Cost of 33 per cent. of 4·7 lbs. of *Solignum* required per sleeper, for 970 metre-gauge sleepers, costing Rs. 3 per gallon	454	11	0
Cost of 66 per cent. of 4·7 lbs. of *Liquid Fuel* oil required per sleeper, for 970 metre-gauge sleepers, costing 4 annas per gallon in Rangoon	76	0	0
Coolie wages, fuel, and miscellaneous expenses incurred in treatment	296	14	0
5 per cent. on cost of plant	51	0	0
2 per cent. loss by evaporation and leakage . . .	9	0	0
Total cost of treating 970 metre-gauge *Dipterocarp* sleepers	2,100	1	0

Average cost of treating a metre-gauge *Dipterocarp* sleeper = Rs. 2 2 8

The cost of felling, conversion and extraction per metre-gauge sleeper comes to slightly under Re. 1-4-0; the cost of treatment was therefore Re. 0-14-8, to which would have to be added at least 7 annas 4 pies for royalty on the timber and for treatment, making a total of Rs. 2-10-0 per metre-gauge sleeper.

(*c*) *Cost of treating 460* Terminalia tomentosa *broad gauge sleepers with a mixture of 33 per cent. of* Solignum *and 66 per cent. of* Liquid Fuel *oil.*

	Rs.	A.	P.
Cost of felling, conversion and extraction of 460 broad gauge sleepers	1,561	2	0
Cost of ⅓rd of 10 lbs. of *Solignum* per sleeper, for 460 broad gauge sleepers, costing Rs. 3-0-0 per gallon .	460	0	0
Cost of ⅔rd of 10 lbs. of *Liquid Fuel* oil, required per sleeper, for 460 broad gauge sleepers, 5 annas per gallon, including freight	95	11	0
Coolie labour, fuel and miscellaneous charges . .	116	0	0
5 per cent. on cost of plant	17	0	0
2 per cent. due to leakage and evaporation of oil . .	11	2	0
Total cost of treating 460 broad gauge *Terminalia tomentosa* sleepers	2,260	15	0

Average cost of treatment per broad gauge *Terminalia tomentosa* sleeper = Rs. 4-14-8.

(iv) NOTES ON THE BEHAVIOUR OF SLEEPERS TREATED WITH *Solignum* AND *Liquid Fuel* OIL, AFTER HAVING BEEN LAID IN THE LINE.

The *Dipterocarp* sleepers, treated with *Solignum* and *Liquid Fuel,* were laid down in June 1914, the *Pine* and *Deodar* sleepers in November of the same year, and the *Terminalia* sleepers in June 1915, so that not until a further period of 2 or 3 years has lapsed can anything approaching reliable results be expected. It is, however, necessary to place on record where and under what conditions, the sleepers have been laid.

TABLE XXIV.

Record of sleepers treated with Solignum *and* Liquid Fuel *oil and laid for experimental purposes in different sections of the line.*

Species.	Number of sleepers laid down.	Locality where laid down.	Date of laying in line.	Date of last inspection.	Inspection notes.	REMARKS.
Pinus longifolia, or 'Chir.'	83 broad gauge sleepers.	Between Sohanwala and Amruka, mile 149/16-17, Ferozepur District, North-Western Railway.	November 1914	1st March 1917	Sixty-six slightly cracked and three attacked by white-ants, rest in good order. (Inspected by Mr. Sham Lal, North-Western Railway.)	Laid with bearing-plates Branded P. L. / S.L.F.
Ditto	Do.	Between Fazilka and Ladhuka, mile 123/15-17, Ferozepur District, North-Western Railway.	Do.	Do.	Sixty-four slightly cracked, and one attacked by white-ants, rest in good order. (Inspected by Mr. Sham Lal, North-Western Railway.)	Do.
Ditto	Do.	Between Gurubarsahai and Jhok Tahl Singh, mile 95/6-7, Ferozepur District, North-Western Railway.	Do.	3rd March 1917	Sixty-eight slightly cracked and three attacked by white-ants, rest in good order. (Inspected by Mr. Sham Lal, North-Western Railway.)	Do.
Pinus excelsa, or 'Kail.'	33 broad gauge sleepers.	Between Sohanwala and Amruka, mile 149/16-17, Ferozepur District, North-Western Railway.	Do.	1st March 1917	Twenty-four slightly cracked, rest in good order. (Inspected by Mr. Sham Lal, North-Western Railway.)	Laid with bearing plates Branded P. E. / S. L. F.
Ditto	Do.	Between Fazilka and Ladhuka, mile 123/15-17, Ferozepur District, North-Western Railway.	Do.	Do.	Twenty-five slightly cracked, and one attacked by white-ants, rest in good order. (Inspected by Mr. Sham Lal, North-Western Railway.)	Do.
Ditto	34 broad gauge sleepers.	Between Gurubarsahai and Jhok Tahl Singh, mile 95/6-7, Ferozepur District, North-Western Railway.	Do.	3rd March 1917	Twenty-three slightly cracked, and one attacked by white-ants, rest in good order. (Inspected by Mr. Sham Lal, North-Western Railway.)	Do.

Dipterocarpus tuberculatus, or 'In.'	30 metre-gauge sleepers, treated with Liquid Fuel only.	Pyinmana, mile 225/14¾ 15¼, Burma Railways.	22nd June 1914	3rd June 1916 .	Very good, not rotting, all holding well. (Inspected by A. Rodger, Esq., Forest Research Officer, Burma, and Assistant Engineer, Yamethin.)	Marked D. T. / L. F.
Ditto .	470 metre-gauge sleepers treated with *Solignum* and *Liquid Fuel*.	Pyinmana, mile 225/19½ to 226/4¼, Burma Railways.	Do. .	Do. .	All good, a few slightly cracked, not rotting. (Inspected by A. Rodger, Esq., Forest Research Officer, Burma, and Assistant Engineer, Yamethin.)	Marked D. T. / S. L. F.
Dipterocarpus alatus or 'Kanyin.'	500 metre-gauge sleepers.	Pyinmana, mile 225/15¼ to 225/19¼, Burma Railways.	Do. .	Do. .	All good, a few cracked, and one or two beginning to rot. (Inspected by A. Rodger, Esq., Forest Research Officer, Burma, and Assistant Engineer, Yamethin.)	Marked D. A. / S. L. F.
Terminalia tomentosa or 'Sain.'	460 broad gauge sleepers.	Near entrance to Parassia Station, mile 598/78 to 596/97, Itarsi-Nagpur Railway, Great Indian Peninsula.	9th June 1915 .	6th July 1916 .	Up to the present these sleepers are very good. I can see no signs of decay. (Inspected by the Chief Engineer, Great Indian Peninsula Railway).	Branded T. T. / S. L. F.
Cedrus Deodara or 'Deodar.'	16 broad gauge sleepers.	Between Sohanwala and Amruka, mile 149/16-17, Ferozepur District, North-Western Railway.	November 1914	1st March 1917.	Nine slightly cracked, rest in good order. (Inspected by Mr. Sham Lal, North-Western Railway.)	Branded C. D. / S. L. F.
Ditto .	18 broad gauge sleepers.	Between Gurubarsahai and Jhok Tahl Singh, mile 95/6-7, Ferozepur District, North-Western Railway.	Do. .	3rd March 1917 .	Nine slightly cracked, rest in good order. (Inspected by Mr. Sham Lal, North-Western Railway.)	Do.
Ditto .	16 broad gauge sleepers.	Between Fazilka and Ladhuka, mile 123/15-17, Ferozepur District, North-Western Railway.	Do. .	1st March 1917 .	Four slightly cracked, rest in good order. (Inspected by Mr. Sham Lal, North-Western Railway.)	Do.

(v) GENERAL CONCLUSIONS BASED ON THE RESULTS OF SLEEPERS TREATED WITH *Solignum* AND *Liquid Fuel* OIL AND LAID IN THE LINE.

The sleepers which have been in the line from 2 to 3 years are so far doing quite well. The only data available at present, from which it is possible to draw definite conclusions, is the figure of cost of treating sleepers with mixed oils. The cost of treating *Pine* broad gauge sleepers comes to Re. 1-9-10, that of *Dipterocarp* metre-gauge sleepers to Re. 0-14-8 and that of *Terminalia tomentosa* broad gauge sleepers to Re. 1-8-4. The amount of oil introduced was not up to that usually used in treating sleepers; nevertheless, the cost is high and, though possibly not prohibitive, it is questionable whether the results obtained will justify the use of so expensive an oil as *Solignum*. Possibly a far cheaper grade of *coal-tar creosote*, such as *Green oil*, would answer the purpose equally well, which would at the same time reduce the cost of treatment to somewhere about Re. 1-0-0 per broad gauge sleeper, while the amount of oil admissible would be greater than that actually used in the above experiments.

10. General Conclusions arrived at from the above Experiments.

The merits and defects of the various processes above described have been discussed in detail under their separate headings, so that it is here only proposed to briefly review the results from a general point of view.

The experiments demonstrate in a striking manner the possibilities and limitations of the Open Tank Process of treatment. In its favour, it may be said that it is a simple process when compared with those involving pressure; that the period of immersion necessary in the case of soft-woods is not excessive, while that necessary for hard-woods limits the possible number of sleepers to be treated, unless the plant units be multiplied beyond working limits. Thus, any schemes involving the treatment of more than 50,000 *Pine* sleepers or more than 25,000 hard-wood sleepers per annum should not be based on the Open Tank Treatment, as greater quantities of sleepers could more effectively be treated in pressure cylinders.

As regards absorption of an antiseptic solution by timber when treated in Open Tanks, unless the timber be exceptionally easy to treat or the period of immersion be unduly long, the sleepers rarely take up on an average more than 5 to 6 lbs. per cubic foot. It is true that sappy 'Chir' sleepers have been known to take up as much as 15 lbs. per cubic

foot, but this is not the rule. A heart-wood 'Chir' sleeper will take up 5 lbs. to 6 lbs. per cubic foot within 18 to 24 hours, while a combined sap and heart-wood 'Chir' will take up the same quantity in 6 to 10 hours, according to its dryness. Both *Dipterocarps* and *Terminalia tomentosa* will take up 3 to 4 lbs. per cubic foot in 24 hours and, if immersed for a longer period, take up very little extra oil. It may, therefore, be said that in Open Tanks, when working with sleeper sizes, the outside working limit is 6 lbs. per cubic foot under favourable conditions.

The choice of antiseptics in these experiments was governed by their efficiency combined with cheapness, and though the results did not, in some cases, justify their selection, the general lines adopted are thought to have been correct. To form a correct idea as the cost of treatment it is necessary to compare the figures obtained, with the cost of treatment generally adopted in Europe and America, when using a full charge of *coal-tar creosote* which, in India, would amount to Rs. 2-4-0 per broad gauge sleeper.

In comparison with this figure, all our results compare most favourably; nevertheless, in some cases, the actual cost of treatment was excessive, as in the case of *Terminalia tomentosa* broad gauge sleepers, treated with *Solignum* and *Liquid Fuel* oil, which came to Re. 1-8-4 and of *Pines*, treated with the same mixture of oils, which came to Re. 1-9-10 per sleeper.

From experience gained in carrying out these experiments, it has been possible to form more correct ideas as to the application of the principles of mixing oils or oils and salts together, in order to reduce cost without, as far as one can see, impairing the toxic value of the solutions.

The first set of experiments deal with *Powellized* timber, a patented process which cannot be altered and therefore the cost of treatment is dependent on the market value of the ingredients used, and though the cost of treatment is relatively high, in favourable localities it cannot be considered as prohibitive.

The second set of experiments were carried out with *Avenarius Carbolineum*, an expensive oil, which introduced in any quantity renders the cost of treatment prohibitive. This oil, when used alone cannot at present be considered for treating sleepers in India as it is too expensive.

The third group of experiments were carried out with *Chloride of Zinc* and either *Green oil* or *Avenarius Carbolineum.* Here we have a relatively cheap process of treatment, when using the salt and *Green oil*, for it only costs Re. 1-1-4 to treat a broad gauge pine sleeper with

15 lbs. of the salt and 4 lbs. of the oil, and 6 annas 5 pies for a *Dipterocarp* metre-gauge sleeper with 9 lbs. of the salt solution and 1 lb. of oil. Without doubt the cost of treatment could be still further reduced, as 6 annas 10 pies per gallon is above the usual rate for *Green oil* in Europe. Or again, a good grade of *Coal-tar* creosote at 4 annas 6 pies per gallon could be substituted, which would further reduce cost of treatment, probably without seriously affecting the efficiency of the process.

The 4th and last group of experiments were carried out with a mixture of *Solignum* and *Petroleum* oils. The oils used were *Solignum* and *Liquid Fuel*; here again costs run higher than they should have done, due to the high price of *Solignum*. However, by applying the principle of mixing *Coal-tar* products with *Petroleum* oils and using, for instance, *Green oil* or a good grade of *creosote*, as used for treating timber in Europe, the results obtained are very different. The mixture instead of costing about Re. 1-10-0 per gallon, as was the case with *Solignum* and *Liquid Fuel*, is reduced to 9 or 10 annas per gallon. Putting the maximum cost of treatment admissible at Re. 1-4-0, this will permit of somewhere in the neighbourhood of 18 lbs. of the solution being introduced per broad gauge sleeper, a larger amount than was used in any of the above experiments.

The durability tests have hardly been carried far enough to justify definite statements being made, while the results have been discussed in detail elsewhere, so need not be dealt with again; sufficient is it to say that to date none of the sleepers have shown any serious signs of failure.

PART IV.

MISCELLANEOUS FIELD EXPERIMENTS CARRIED OUT WITH SLEEPERS TREATED IN OPEN TANKS.

Several experiments in connection with the antiseptic treatment of timber, other than those carried out according to the scheme drawn up at the Forest Research Institute in 1910 and described in Part III of this note, have been made of recent years in India. These experiments were either started by Indian Railway Engineers, or at the instigation of firms interested in any special process or were in the nature of supplementary experiments to those enumerated in Part III, and carried out by the Forest Department. For convenience sake, these experiments are arranged according to the antiseptic employed, irrespective of the agency of treatment.

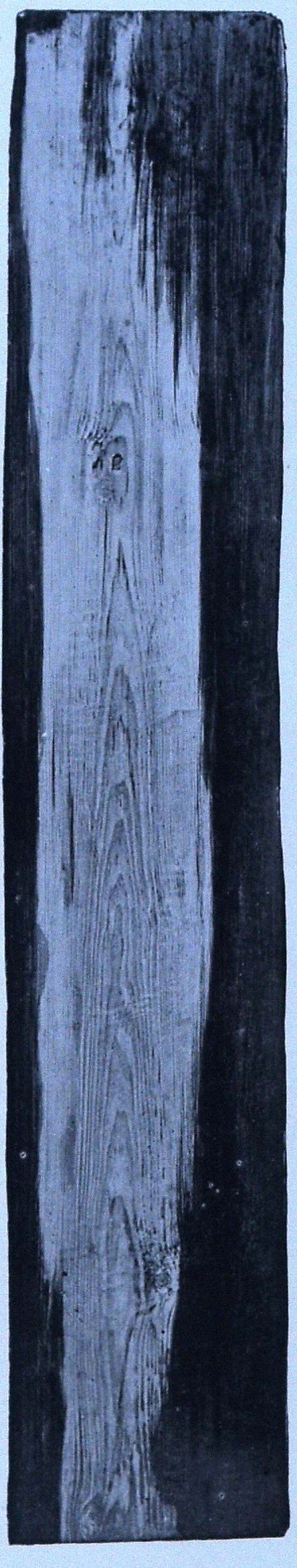

Photo.-Mechl. Dept., Thomason College, Roorkee. Photo by T. B. Chitrakar.

Full cell Open Tank process—*Pinus longifolia* sap and heart-wood $\frac{1}{2}$ section of a sleeper, treated for 8 hours in Creosote and Earth oil, raised to a temperature of 73°C. dropping to 65°C. Absorption 10·3 lbs. per c. ft.

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1. Treatment of sleepers with mixed oils.

(*i*) SPECIAL EXPERIMENTS CARRIED OUT WITH *Pinus longifolia* SLEEPERS TREATED IN OPEN TANKS.

The interest taken by the Railway Authorities in the experiments described in Part III, combined with their urgent need for sleepers, enabled Mr. Hart, the Inspector-General of Forests, to arrange a contract by which the Forest Department was to supply the State Railways with a million treated *Pinus longifolia* broad gauge sleepers within four years. The possibility of carrying out the contract was facilitated by the fact that the United Provinces Forest Department was anxious to place large quantities of this timber on the market from the newly formed Kumaon Circle. In connection with this work, three installations have been erected at Kathgodam and Tanakpur on the Rohilkund and Kumaon Railway, and at Hardwar on the Oudh and Rohilkhand Railway.*

To ascertain the period of immersion necessary, in order to make the sleepers take up 15 lbs. of oil each, experiments were carried out as soon as the first unit of the new plant was in working order. The oil used was a mixture of equal parts, by weight, of *Green oil*, which is a good grade of creosote, with high boiling fractions and *Liquid Fuel* with a *Petroleum* base. Soon after starting the experiments it was ascertained that to obtain more uniform absorption of the oil, it was necessary to divide the sleepers into two groups, according to whether they contained sap-wood in addition to heart-wood or not. Little difficulty has been experienced in doing so, and this procedure has been in force up to date.

* NOTE.—The works have recently been closed, owing to creosote not being available from Europe.

The following are some of the results obtained by treating *Pinus longifolia* broad gauge sleepers in the United Provinces treating tanks :—

TABLE XXV.

Experiments carried out with Pinus longifolia *or 'Chir' broad gauge sleepers in the United Provinces Open Tank installations, at Kathgodam, Tanakpur and Hardwar, to ascertain the necessary period of immersion in order to make the sleepers take up 15 lbs. of oil each.*

Serial No. of experiment.	No. of broad gauge sleepers on which the average is based.	Total period of immersion, in hours.	Temperature of the oil.	Average amount of oil absorbed per sleeper, in lbs.	REMARKS.
	(i) *Heart-wood* Pinus longifolia *broad gauge sleepers.*				
1	20	24	Heated to 81°C. for 4 hours and allowed to cool to 43°C.	16·4	Seasoned sleepers. Experiments carried out by Forest Economist at Kathgodam in April 1914.
2	20	24	Heated to 80°C. for 4 hours, 20 hours cooling to 42°C.	15·4	
3	15	24	Heated to 86°C. for 4 hours, dropping to 41°C.	16·1	
4	10	17	Heating to 80°C., dropping to 45°C.	10·0	
5	20	24	Heating to 80°C., dropping to 40°C.	8·8	Seasoned sleepers, which were launched for floating purposes and taken out of the stream 18 days before treatment. Treated by the Forest Economist at Kathgodam in April 1914.
6	7	15	Heating to 80°C. for 2½ hours.	12·3	Well-seasoned sleepers. Experiments carried out by J. Donald, Esq., and the Senior Provincial Service Class in April 1914 at Kathgodam.
7	19	16	Heating to 83°C., dropping to 52°C.	13·2	Thoroughly seasoned heart-wood sleepers, containing very little sap. Experiments carried out by Forest Economist at Tanakpur in January 1915.
8	19	19	Heating to 93°C., dropping to 60°C.	14·4	
9	18	20	Heating to 93°C., dropping to 50°C.	16·6	
10	18	26	Heating to 85°C. . .	13·1	Seasoned sleepers containing no sap ; the sleepers, however, though seasoned, were damp due to the monsoon rains. Treated by C. E. C. Cox, Esq., Assistant, Forest Economist at Hardwar, in August 1915.
TOTAL .	166	209	....	136·3	
AVERAGE	1	20·9	Heated to 84°C., dropping to 47°C.	13·6	

TABLE XXV—*contd.*

Serial No. of experiment.	No. of broad gauge sleepers on which the average is based.	Total period of immersion in hours.	Temperature of the oil.	Average amount of oil absorbed per sleeper, in lbs.	REMARKS.
			(ii) *Sap and heart-wood* Pinus longifolia *broad gauge sleepers.*		
1	10	17	Heated to 80°C., dropping to 45°C.	17·8	Seasoned sleepers, containing a large proportion of sap-wood. Treated by Forest Economist at Kathgôdam in April 1914.
2	20	9	Heated to 86°C., dropping to 74°C.	7·1	Ditto
3	20	6	Heated to 50°C.	7·5	Ditto
4	20	5	Heated to 90°C. for four hours and allowed to cool to 82°C.	14·5	Very thoroughly seasoned sleepers containing at least ⅓rd sap-wood. Treated by Forest Economist at Tanakpur in January 1915.
5	20	5	Heated to 71°C., dropping to 54°C.	17·1	Ditto
6	16	8	Heated to 80°C., dropping to 65°C.	4·25	Sap-wood sleepers, only having been out of the floating stream 10 days and therefore containing an excess of moisture. Treated by Forest Economist at Tanakpur in January 1915.
7	20	8	Heated to 73°C., dropping to 63°C.	19·1	Very thoroughly seasoned sleepers, 18 months out of floating stream. The sleepers contained on an average one-third of sap. Treated by Forest Economist in November 1915.
TOTAL	126	58	....	87·35	
Average	1	8·3	Heated to 76°C., dropping to 64°C.	12·5	

NOTE.—Omitting No. 6 which contained green sleepers, the average works out to 13·85 lbs. per sleeper.

From the above experiments it was ascertained that—

(*i*) the maximum period of immersion necessary for heart-wood *Pinus longifolia* broad gauge sleepers, in order to make them take 15 lbs. of oil each, is 24 hours, with the temperature of the oil raised to 80°C., maintained at that temperature for 4 hours and then allowed to cool down.

(*ii*) The maximum period of immersion necessary for sleepers containing ⅓rd of sap-wood or more, in order to make them take up 15 lbs. of oil each, is 12 hours, with temperatures as above.

(*iii*) When dealing with sleepers which have been 18 months or more out of the floating stream, 18 hours' immersion for

heart-wood and 6 hours' immersion for sap and heart-wood sleepers is sufficient to make them take up 15 lbs. each.

(*iv*) It is not only useless but wrong to treat sleepers recently taken out of the floating stream, even if they are thoroughly seasoned, before being thrown into the stream for floating purposes. The minimum period for seasoning, after the sleepers have been removed from the floating stream, is 4 months in the cold weather and 3 months in the hot weather.

(*v*) The main factors regulating the rate of absorption of oil by any one species of timber are: (*i*) the percentage of moisture in the timber, at the time of treatment, (*ii*) the difference in the maximum and minimum temperature of the oil during treatment; the greater the difference, the greater the rate of absorption and quantity of oil taken up, (*iii*) the percentage of sap to heart-wood, and (*iv*) structure.

(*ii*) TREATMENT OF ASSAM SPECIES OF TIMBER IN OPEN TANKS.

In 1912, when the writer was on tour in Assam, the question of supplying the Assam-Bengal Railway with treated sleepers came under discussion, and proposals were made to carry out experiments with a species of timber known as *Cynometra polyandra*; later, the scope of scheme was further extended by Mr. Perreé, the then Conservator of Forests of the Eastern Circle, by the addition of other species of timber. Under his directions, an experimental Open Tank plant was erected at Jaipur by Mr. Cooper, the Divisional Forest Officer of the Lakhimpur Division, and the sleepers for the experiment prepared and seasoned. In February 1915, Messrs. Perreé and Cooper, in company with the writer, proceeded to Jaipur to carry out these experiments.

The species of timber selected for testing were (*i*) *Artocarpus Chaplasha* 'Cham,' (*ii*) *Dipterocarpus pilosus* 'Hollong,' (*iii*) *Altingia excelsa* 'Jutuli,' (*iv*) *Cynometra polyandra* 'Ping', (*v*) *Terminalia myriocarpa* 'Hollock' and (*vi*) *Terminalia belerica* 'Bhumra.'

The timber was allowed to season in the log and was then cut into metre-gauge sleepers and allowed further to season under cover for from 8 months to 2 years. The timber was, therefore, thoroughly dry, while the absence of cracks was very noticeable, an important point demonstrating the great value of slow and thorough seasoning.

The solution used to treat the sleepers was *Green oil* and crude *Earth* or *Petroleum* oil, mixed in equal quantities by weight.

The results of the experiments are tabulated below :—

TABLE XXVI.

Experiments carried out at Jaipur, Lakhimpur Division, Assam, to ascertain the penetration of oil into 8 Assam species of timber, when treated in Open Tanks.

Serial No. of experiments.	Species.	No. of metre-gauge sleepers, on which the average is based.	Total period of immersion, in hours.	Temperature of the oil.	Average amount of oil absorbed per sleeper, in lbs.	REMARKS.
1	*Artocarpus Chaplasha* 'Cham.'	2	24	Heated from 85°C. to 93°C., dropping to 35°C.	0·5	Practically no penetration at all.
2	*Dipterocarpus pilosus* 'Hollong.'	10	24	Ditto .	9·7	The absorption was on the whole uniform, the extremes being 6·5 lbs. and 14 lbs. per sleeper.
3	*Altingia excelsa* 'Jutuli'	8	24	Ditto .	4·25	Absorption irregular, varying from 1 lb. to 7·5 lbs. per sleeper.
4	*Cynometra polyandra* 'Ping'.	8	24	Ditto .	9·2	Absorption irregular, varying from 3·5 lbs. to 18 lbs. per sleeper.
5	*Terminalia myriocarpa* 'Hollock.'	2	24	Ditto .	2·75	Absorption indifferent.
6	*Terminalia belerica* 'Bhumra.'	2	24	Ditto .	25	Absorption excessive, a soft timber, hardly suitable for sleepers.

The above experiments, though only carried out on a small scale, indicate that it is possible to treat *Dipterocarpus pilosus* 'Hollong,' *Terminalia belerica* 'Bhumra,' and *Cynometra polyandra* or 'Ping' by the *Open Tank* process. Of these timbers, *Terminalia belerica* is mechanically hardly strong enough to be used for sleepers; *Dipterocarpus pilosus* is a good straight-grained timber which, owing to the large pores in the timber readily absorbs any solution in which it is placed. *Cynometra polyandra* is a hard timber, and it therefore came as somewhat of a surprise that it took up the oil so readily. *Terminalia myriocarpa* and *Artocarpus Chaplasha* do not lend themselves to treatment in Open Tanks; in fact, attempts to treat the former timber under pressure were equally unsuccessful. This is to be regretted as both are sound good timbers, though not sufficiently durable for sleeper work, unless previously treated with a suitable antiseptic. The remaining species, namely, *Altingia excelsa* took up relatively small quantities of oil, though it would probably lend itself to pressure treatment.

These sleepers, together with a number of sleepers treated under pressure, the record of which work is given in the next chapter, were laid down in the Assam-Bengal Railway in October and November 1915, and are to be kept under observation. As they have not been in the line a year, their condition is not recorded.

(*iii*) TREATMENT OF *Dipterocarpus turbinatus*, 'GURJAN' BROAD GAUGE SLEEPERS OBTAINED FROM THE ANDAMANS, IN OPEN TANKS.

A scheme having been put forward to supply the State Railways with treated *Dipterocarp* sleepers from the Andamans, a sample lot of seasoned broad gauge Gurjan sleepers were submitted, for testing their power of absorption in Open Tanks. Twenty sleepers were immersed for 24 hours in a mixture of *Green oil* and *Liquid Fuel* oil, heated for 5 hours to 72°C. and allowed to cool down in the bath for a further period of 19 hours. This resulted in the sleepers taking up an average of 15·1 lbs. each. One or two of the sleepers took up an excessive amount of oil, amounting to 28 lbs., while a few only took up 4 to 6 lbs; on the whole, however, the absorption was fairly regular. It is evident that this species of timber is not difficult to treat even in Open Tanks, though probably quicker and better results would be obtained by treating it under pressure.

2. Sleepers treated with Crésol-Calcium.

In December 1910, the North-Western Railway laid down, as an experiment, 499 Swedish pine sleepers treated with *Crésol-Calcium.*

These sleepers were supplied by the *Crésol-Calcium* Impregnating Aktiebolag Company and laid by the North-Western Railway from mile 315/12 to 315/18, between Sangi and Pans Akil stations on the Sukkur Section.

The latest report submitted by the Executive Engineer, Sukkur, dated 24th October 1915, on the condition of these sleepers, states that one has been rejected, due to attack by white-ants, and puts 120 into A class, 250 into B class and 123 into C class. The reason for classifying 373 sleepers in classes B and C is due to the ends having cracked and split and is not due to white-ant attacks. The cut under the bearing plates is reported as not severe, while the spikes are holding well. The report states that some of the C class sleepers are now hardly serviceable for the main line where trains run at a high speed.

The point of interest about this experiment is that the sleepers, with the exception of one, have not been touched by white-ants, in a section of the line which is notorious for these pests. These sleepers are laid in continuation of the *Powellized sleepers*, the records of which are given in the previous chapter, which have also so far withstood the ravages of white-ants. It may be stated here that untreated Jarrah, and also in some cases untreated Deodar, have suffered heavily from white-ant attacks in this section of the North-Western Railway.

3. Sleepers treated with Jodelite and laid in the Burma Railways.

In Chapter III are recorded the results of experiments carried out in Burma with a few *Powellized* species; at the same time as these sleepers were laid down, a similar set of sleepers treated with *Jodelite* were placed alongside them. Exactly how the sleepers were treated with *Jodelite* is not recorded, but it is thought that the solution was applied with a brush, giving the timber one or more coats of the oil. These experiments are of interest having been in progress longer than any others in British India. The results of an inspection carried out on the 3rd June 1916 by A. Rodger, Esq., Forest Research Officer, Burma, and the Assistant Engineer, Yamethin, are as follows :—

TABLE XXVII.

Record of sleepers treated with Jodelite.

No.	Species.	Sleepers treated with *Jodelite*.			Untreated sleepers.		
		No. laid down.	Date of laying in line.	Condition.	No. laid down.	Date of laying in line.	Condition.
1	*Dipterocarpus tuberculatus*, or 'In.'	10	15th April 1908.	The 5 left in 1915 are still in the line, one must be removed, as it is badly cracked and rails have eaten in.	10	15th April 1908.	The two remaining sleepers seen in 1915 have been removed, rotten and cracked.
2	*Dipterocarpus alatus* or 'Kanyin.'	10	Do.	All removed in 1911-12. (Experiment closed.)	10	Do.	All removed in 1913.
3	*Homalium tomentosum* or 'Myoukchow.'	10	Do.	Only two left, spikes do not bite at all well, slightly cracked, otherwise good, no sign of rot.	10	15th April 1907.	All removed by 1911.
4	*Schleichera trijuga* or 'Gya.'	10	Do.	All removed by 1912.	10	Do.	All removed by 1913.
5	*Terminalia belerica* or 'Thitsein.'	10	Do.	All removed by 1911.	10	Do.	All removed by 1909.
6	*Terminalia tomentosa* or 'Taukkyam.'	10	Do.	5 are left, one must come out, all rather cracked, but good for another year. Spikes holding. Rails have not cut into the timber badly.	10	Do.	All removed by 1913.
7	*Lagerstrœmia tomentosa* or 'Lezo.'	10	Do.	Only one left, but it is badly split and spikes not holding. May last another year.	10	April 1908.	All removed in 1912.

The results of the above experiments show that 50 per cent. of the *Dipterocarpus tuberculatus* and *Terminalia tomentosa* sleepers are still in the line after more than eight years, while the first-named species has only a life of 4 to 5 years in an untreated state. Five out of ten of the *Terminalia tomentosa* sleepers are still present, as against all the untreated sleepers removed in five years. The other species of timber have given poor results. It was stated above that the method of treatment was probably by applying one or more coatings of the solution which, generally speaking, is not sufficient to protect sleeper woods from decay.

PART V.

RECORDS OF EXPERIMENTS CARRIED OUT WITH SLEEPERS TREATED IN PRESSURE PLANTS WITH INDIAN AND OTHER VARIETIES OF TIMBER.

1. Records of former Experiments carried out in Pressure plants, previous to 1910.

In *Indian Forest Records*, Volume III, Part II, on pages 17-23, is given a brief record of the experiments carried out in the past on timber treated under pressure in India while, in a letter from the Secretary to the Railway Board to the Inspector-General of Forests to the Government of India, a résumé is also given of the work carried out in past years. As this letter is an open one and clearly and briefly sums up the position of affairs as it stood in India in 1910, it is given here in full.

"In reply to your letter No. 1406-394—1, dated 28th October 1909, I am directed to say that papers available in this office contain no records of any systematic experiments carried out on Indian Railways with impregnated sleepers, nor is there a careful record of trials made with woods other than *Deodar*, *Sal* and *Pyingado* in their natural state. Railway Administrations have, from time to time, endeavoured to meet the rise in the prices of recognized and well-tried varieties of timber by introducing new varieties, or by artificially improving the existing ones. The experiments which have been made have not, however, met with any considerable measure of success, and it was found that these expedients could not compete economically with the well-established varieties such as *Deodar*, *Sal* and *Pyingado*.

"The Board are not aware to what extent you wish to investigate the subject, but they understand from your enquiry that you only ask for data which may be available in their office. I am, therefore, to

communicate the following particulars and to say that if further details are required, it will be necessary to refer to the Railway Administration concerned."

2. I.—EXPERIMENTS CARRIED OUT WITH IMPREGNATED SLEEPERS.

"Omitting the *Powellizing* process which is now being tried for Railway sleepers, under the direction of the Imperial Forest Economist, experiments on Indian Railways have been practically limited to two processes (*A*) *Creosoting*, and (*B*) the *Haskin* process.

3. (A) CREOSOTING.

"In the infancy of Indian Railways, practice was modelled very largely on that existing in England, creosoted pine sleepers were imported to a considerable extent and were found fairly successful. In 1866 the East Indian Railway with a view to making use of certain species of soft pines and firs available in Northern India, imported a creosoting plant for the purpose of treating these sleepers. The cost of these sleepers was, however, found to be prohibitive and the plant was abandoned and sold as scrap iron many years ago.

"Creosoted pine, imported from England, continued to be used for some years by Railways having access to the western ports of India. Thus, on the North-Western Railway, some creosote pine sleepers were laid on the Kotri-Rohri section in 1897. These sleepers were *Baltic red pine* imported under I. O. Contracts No. 40-240—242, dated 23rd November 1894, and No. 48-151, dated 10th September 1895. It is believed that all these sleepers have, since 1897, been replaced by sleepers of other varieties.

"A large number of creopine sleepers were also laid on the Southern Punjab Railway previous to the year 1904 and were estimated to last from 7 to 12 years.

"The use of these imported creosoted pine sleepers has been discouraged by the Consulting Engineers to the India Office, and no sleepers of this kind have been used of recent years on State Railways. Information regarding other Railways is very scanty, but it is known that in former years the Bombay, Baroda and Central India Railway imported considerable numbers of creosoted pine sleepers; such sleepers were also used by the Bhavnagar-Gondal-Junagad-Porbandar Railway and, to a very limited extent, by the Great Indian Peninsula Railway.

4. (B) THE HASKIN PROCESS.

"In November 1899, at the suggestion of the Consulting Engineer for Railways, the Government of India (Public Works Department)

circulated for remarks certain proposals for setting up installations for *Haskinizing* sleepers at a few centres. The replies of Railway officers varied considerably. While some welcomed the proposals, others anticipated that they would never lead to economy and therefore to success, and on the whole the general opinion was unfavourable to the introduction of *Haskinizing* installations in India.

"The Government of India's enquiry in 1899 elicited the information that the Bombay, Baroda and Central India and the Burma Railways already had some experience with the *Haskin* process, the particulars of which are given briefly below.

"The Bombay, Baroda and Central India Railway reported that they had recently laid some 5,000 *Haskinized* sleepers on their road, chiefly in the Bombay and Broach Divisions. The report on these sleepers was necessarily incomplete as they had only been laid a short time. It appeared, however, that after a period of about two years, the sleepers laid in the Broach Division were found to be much attacked by white-ants, and the opinion of the Engineers generally was that these *Haskinized* sleepers were inferior to *creosoted* ones.

"The Government of Burma reported in April 1901 that certain scantlings, vulcanized by the Haskin process, had been obtained and fixed on the ground at Rangoon for observation; the results of the experiments were communicated in December 1901, and are shown in the statement attached as Appendix A. These results are not very conclusive, and nothing further seems to have been done with a view to enlarging the experiment.

"The question of the introduction of *Haskinizing* installations in India then appears to have been dropped."

2. Records of Experiments carried out in Pressure plants, subsequent to 1910.

After the laboratory and field experiments, carried out with various species of Indian timber treated in Open Tanks had proceeded up to a certain point, sufficient data were available and experience was gained to form a fair idea of the possibilities and limitations of this method of treating timber. It was found that though Indian Pines and certain softer timbers could be treated by a simple Open Tank process, the *Dipterocarps* and other harder species of timber, with possibly the exception of *Dipterocarpus pilosus*, could probably be better dealt with under pressure. At that time no pressure plant was available in India with which to carry out such tests; so, as a commencement, a batch of sleepers of Indian timbers were sent to England to be tested. Later,

through the good offices of Messrs. The Assam Oil Co., a small experimental plant was erected at their works in Assam, while quite recently, Government have ordered an up-to-date experimental plant from Home, to be erected at the Forest Research Institute, Dehra Dun. In spite of the want of proper equipment to carry out experiments of this class, some very valuable preliminary information has been collected as to the possibility of treating Indian timbers under pressure, the results of which are given below.

(*i*) TREATMENT OF ASSAM SPECIES OF TIMBER UNDER PRESSURE AT DIGBOI, ASSAM.

In 1914, while on tour in Assam, Mr. Hart, the Inspector-General of Forests, arranged with the Honourable Mr. A. B. Hawkins, Manager of Messrs. The Assam Oil Co., to erect a small pressure plant at their works. The necessary sleepers having been prepared and seasoned by Mr. Cooper, the Divisional Forest Officer, Lakhimpur, the writer proceeded to Assam in February 1915, to carry out the experiments. Of these sleepers, *Dipterocarpus pilosus* (Hollong) were cut between January and May 1913 and converted in June and July 1914, placed under cover in August of the same year and treated in February 1915. The timber was therefore felled two years before treatment. Moisture tests taken showed the air-dry wood to contain 27·45 per cent. of moisture at the time of treatment, while absolutely green wood of the same species was found to contain 45·37 per cent. of moisture. The *Terminalia myriocarpa* or 'Hollock' timber, was cut in June and July of 1914, the sleepers being prepared in July and August of the same year and treated in February 1915. The sleepers, therefore, had 8 months within which to season. Moisture tests showed these sleepers to contain 29·27 per cent. of moisture against 44·43 per cent. in absolutely green timber.

The primary object of the experiment was to ascertain whether *Dipterocarpus pilosus* (Hollong) and *Terminalia myriocarpa* (Hollock), timber could be treated under pressure, though other species were also included ; and, if so, the best method of carrying out the work, *i.e.*, the necessary period of treatment, the pressure required to make the timber take up the required quantity of oil, the initial vacuum if any required, the degree of seasoning necessary to allow of proper treatment and the final durability of the timber.

The plant consisted of an iron cylinder, 8 feet long and 2 feet 2 inches diameter, fitted with a removable end, the cylinder being capable of taking a charge of 7 metre-gauge sleepers and to withstand a pressure of over 200 lbs. per square inch. To the cylinder was connected pressure and

Photo by R. S. Pearson.

Photo.-Mechl. Dept., Thomason College, Roorkee.

Experimental Pressure Treating plant, property of Messrs. the Assam Oil Co., Ltd., Digboi, Assam.

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vacuum pumps, the necessary gauges and a melting tank, fitted with a steam coil.

The question of the percentage of the moisture in the timber at the time of treatment being of vital importance, will be again referred to later on.

The oil used for treating the sleepers was *Green oil* and *Liquid Fuel* or *Earth oil*, mixed in equal proportions, by weight. The grade of *Earth oil* used is known as " wax drippings " and has a specific gravity of ·846, containing a high percentage of wax and an initial boiling point of 190° C. The *Green oil* used had a specific gravity of 1·095 and an initial boiling point of 221°C. The mixture commenced to boil at 190°C. and had a specific gravity of ·950. In one experiment *Earth oil* only was used.

In each case the sleepers after being charged into the cylinder were subjected to live steam for a fixed period, followed by a vacuum of upwards of 22 inches on the column of mercury. The oil heated to about 75°C., was then run into the cylinder by the vacuum suction, after which the pressure was applied, in the case of *Dipterocarpus pilosus* (Hollong), starting with the first charge at 100 lbs. per square inch, and dropping the pressure in each successive experiment until 20 lbs. per square inch was reached. In the case of *Terminalia myriocapa* (Hollock), which did not take up the oil so readily, the first charge of sleepers was subjected to 100lbs. and the last to 200 lbs. pressure per square inch. In the last experiment with " Hollong ' metre-gauge sleepers, a final vacuum was applied for an hour, in order to suck out the excess oil absorbed by the sleepers. *Bischofia javanica* sleepers were also tested, and subjected to 200lbs. pressure though, even at this pressure, poor results were obtained.

The cylinder being of very limited dimensions, it was only possible for the writer to treat relatively few sleepers so that, after having fixed the essential points, the rest of the sleepers destined to be supplied to the Railways for this experiment were treated on the same lines by Messrs. The Assam Oil Co.

The results of these experiments are tabulated below :—

TABLE XXVIII.

Experiments carried out at Digboi, Assam, to ascertain the absorption of oil by certain Assam species of timber, when treated under pressure.

Oil used in treatment.	Serial No. of experiment.	Species.	No. of metre-gauge sleepers on which the average is based.	Method of treatment.				Final vacuum, if any.	Average quantity of oil absorbed in lbs.	Remarks.
				Period of steaming.	Vacuum, inches on column of mercury.	Temperature of oil.	Pressure applied.			
Green oil and *Wax drippings*, mixed in equal proportions, by weight.	I	*Dipterocarpus pilosus*, or 'Hollong' air-dried metre-gauge sleepers.	7	15 minutes at atmospheric pressure.	1 hour at 17·5 inches.	75°C.	1 hour at 100 lbs. pressure.	*Nil*	19·56 lbs. per sleeper or 13·56 lbs. per cubic ft.	The sleepers were air-dried, containing 27·45 per cent. of moisture. However, just before treatment, a sharp shower of rain fell damping the surface of the timber. On a sleeper being cut open, it was found that the oil had penetrated throughout the timber.
	II	Ditto . .	7	½ hour atmospheric pressure.	3½ hours rising to 20 inches.	78°C.	3½ hours at 10 lbs. pressure.	*Nil*	16·97 lbs. per sleeper or 11·32 lbs. per cubic ft.	Ditto
	III	Ditto . .	7	15 minutes at 20 lbs. pressure.	1 hour at 20 inches.	70°C.	½ hour at 50 lbs. pressure.	*Nil*	15·8 lbs. per sleeper or 10·53 lbs. per cubic ft.	Air-dried timber.
"C" grade Earth oil only.	IV	Ditto . .	5	Ditto .	35 minutes at 20 inches.	72°C.	Ditto .	*Nil*	17·2 lbs. per sleeper, or 11·46 per cubic ft.	Ditto

The conclusions arrived at from these experiments may be summarized as follows :—

(*a*) That *Dipterocarpus pilosus*, or 'Hollong' timber treats with great ease when immersed in oil and subjected to pressure. With a 100 lbs. pressure kept up for an hour (Experiment I), metre-gauge sleepers each took up 19·56 lbs. of oil, which is considerably more than is necessary. When subjected to 20 lbs. pressure for 15 minutes (Experiment V), the sleepers took up 11·2 lbs. each. The oil penetrated to the centre of the sleepers under 100 lbs. pressure and very nearly so when subjected to 20 lbs. pressure. Looking to the nature of the timber, which is very straight-grained with large pores and to the climatic conditions prevailing in Assam and parts of Bengal, where such treated sleepers are likely to be laid down, it would be advisable to treat them with anything from 9 to 12 lbs. of oil per metre-gauge sleeper or 6 lbs. to 8 lbs. per cubic foot. It is obvious that the oil will evaporate in direct proportion to the size of the pores and hence the necessity for more completely impregnating the whole tissue. To do so, it will be necessary to steam the sleepers for 10 minutes at a pressure of 10 lbs., to apply a vacuum of 10 inches for 10 minutes, to run in the oil at from 75°C. to 80°C., and apply a pressure of from 20 to 25 lbs. per square inch for 15 minutes, according to the degree of the seasoning.

(*b*) That *Terminalia myriocarpa*, or 'Hollock' requires more drastic treatment than 'Hollong,' owing to the fact that the timber is denser and harder and contains fewer pores, generally set obliquely one to the other as is characteristic of the timber of most *Terminalias*. In the experiments carried out with 'Hollock,' the absorption amounted to 5·3 lbs. with a pressure of 100 lbs. applied for one hour (Experiment No. VIII) and 8·6 lbs. per sleeper with a pressure of 200 lbs. for two hours (Experiment No. X). Probably, by increasing the time during which the pressure is applied from 2 hours to 4 hours, the impregnation could be increased to about 10 lbs. per metre-gauge sleeper while, looking to the good quality of this timber, not more than 10 lbs. per metre-gauge sleeper is considered necessary. To obtain this absorption, steaming should be carried out for one hour at 20 lbs. pressure, followed by a vacuum of 20 inches for one hour, the oil run in at 75°C. and the pressure kept at between 175 lbs. and 200 lbs., according to the degree of seasoning of timber. As an alternative to

the above procedure, as this timber is difficult to impregnate, attempts might be made to treat it by boiling in the oil under a 20 inches vacuum for 2 hours, at a temperature of 115°C., then applying a pressure of 150 lbs. for 3 hours, by doing so the treatment would probably be facilitated.

(*c*) That *Bischofia javanica*, or 'Uriam' is very difficult to treat owing to its dense nature (Experiments XI and XII). The sleepers were obtained from the Dibru-Sadia Railway Company, but their exact degree of dryness when treated was not known; they appeared, however, to be only partially seasoned. Before definitely stating that this timber is unsuitable for treatment, it would be necessary to carry out further experiments with thoroughly seasoned timber, and to treat it in the same way as is advocated for *Terminalia myriocarpa*.

(*d*) That the 'Hollong' (*Dipterocarpus pilosus*) and 'Hollock' (*Terminalia myriocarpa*) sleepers, which had been seasoning for upwards of 2 years and 8 months respectively, cannot be considered to be thoroughly air-dried, as the former contained 27·45 per cent. and the latter 29·27 per cent. of moisture. Taking into consideration the time during which these sleepers had been seasoning, it is probable that the percentage of moisture in the timber represents the degree of dryness to which the timber attains in the damp climate of Assam. No doubt the sleepers, on being placed in a well-drained and dry ballasted line, even in Assam, would dry out further, as a railway track at certain times of the year is as hot a place as can be found; nevertheless, it is thought that the additional moisture which may be lost after placing such sleepers in the line, will not be sufficient to cause excessive cracking of the timber. Were the sleepers destined for one of the Central India, United Provinces or Punjab Railways, or, in other words, to be placed in a dry, hot climate, there is little doubt that the timber would have to be further seasoned before treatment, either by artificial means or by taking it to a dry, hot climate, and allowing it to further season before treatment.

(*e*) That the treatment of green timber is altogether to be discouraged. In the first place it is more difficult to effect, as will be seen by comparing Experiments I and VI, carried out under identical conditions with air-dry and absolutely green timber; and secondly, an even more important point, ascertained from experience in Europe and America, the

timber treated green has not nearly so long a life as that treated when in an air-dry state.

(*f*) That the absorption by timber when using a mixture of creosote and Earth oil or *Earth oil* only, is practically the same. See Experiments III and IV carried out with the same wood, under similar conditions and with the above two oils.

(*g*) That oil can be recovered in considerable quantities from the timber after it has been forced in under pressure by applying a vacuum (see Experiment VII). This experiment was an extremely interesting one : it was carried out with air-dried 'Hollong' sleepers and the conditions of treatment were identical with those employed in Experiment I, except that a vacuum of 22·5 inches was applied for ½ hour, after the pressure had been released (see Experiment VII). In Experiment I, the sleepers took up 19·56 lbs. each, and in Experiment VII they took up 12·7 lbs. each, and it is reasonable to suppose that those in Experiment VII had taken up the same amount of oil as those in Experiment I before the final vacuum was applied. The actual difference in the amount of oil absorbed in these two sets of sleepers amounts to 6·86 lbs. per sleeper, while the amount of oil recovered in Experiment VII was 42 lbs. from 7 sleepers, or 6 lbs. per sleeper, and as two of the sleepers were green, and therefore gave off slightly less oil, the figure tallies remarkably well. The procedure followed in Experiment VII is that known as the "Open Cell" process, by which the fibre is first thoroughly saturated throughout with oil and the surplus oil removed by vacuum. This process differs from the "Rüping" process, which is also an "Open Cell" method of treatment, in that the surplus oil in the former process is sucked out by vacuum, while in the latter it is expelled by a cushion of air introduced before the oil is forced into the timber. It is unfortunate that no records are available in India as to the relative value of the "Open Cell" and common or "Full Cell" process of treatment, as the only country in which the "Rüping" process has been employed for any length of time is Germany, from which country, at the present time, no information is available. The "Open Cell" process has much to recommend it, especially in India where economy in oil is of paramount importance. The sleepers have been recently placed in the line near Moriani Station, and are being kept under observation.

(*ii*) TREATMENT OF INDIAN SPECIES OF TIMBER BY THE "RÜPING" PROCESS IN ENGLAND.

In order to give Indian timbers treated by the *Rüping* process a fair trial, a consignment of sleepers were sent for treatment to Messrs. Richard Wade, Sons & Co. of Hull, who hold the right to use the patent in England. The first batch received by the firm were treated in the presence of the writer, while the remainder were treated at a later date. The sleepers after treatment were returned to India to be laid in the open line and kept under observation.

The treatment consisted of raising the air pressure to 60 lbs. per square inch, after loading the sleepers in the cylinder, the *creosote* oil was then admitted from an overhead storage tank, in which the pressure was equal to that in the cylinder. On the cylinder being filled, the pressure was raised to 155 lbs. per square inch and maintained at that point for an hour. No vacuum was applied either before or after treatment, nor was the timber subjected to preliminary steaming. The process is based on the assumption that, by first introducing air in the timber, the intercellular spaces are filled with compressed air, the oil being introduced at a higher pressure is forced into the timber, driving the air before it and thus forming a cushion of compressed air which, on the pressure being released, drives out the surplus oil from the cells. That this is the case there can be no doubt, as the oil may be seen exuding from the ends of the timber after the pressure has been dropped and the timber removed from the cylinder. The results obtained by treating various species of Indian timber, according to this process, are tabulated below :—

TABLE XXIX.

Results of treating Indian species of timber according to the Rüping *process at Hull, England.*

Oil used in treatment.	Serial No. of experiment.	Species.	No. of M. G. sleepers on which the average is based.	Average quantity of oil absorbed, in lbs.	REMARKS.
A good grade of coal-tar creosote.	I	*Dipterocarpus turbinatus* or 'Gurjan', from Andamans.	7	4·57 lbs. per c. ft. or 6·85 lbs. per M. G. sleeper.	Fair penetration.
	II	*Dipterocarpus tuberculatus*, or 'In', from Burma.	7	1·77 lbs. per c. ft. or 2·65 lbs. per M. G. sleeper.	Absorption probably insufficient to protect the timber.
	III	*Dipterocarpus alatus* or 'Kanyin', from Burma.	8	4·83 lbs. per c. ft. or 7·25 lbs. per M. G. sleeper.	Fair penetration.
	IV	*Dipterocarpus pilosus* or 'Hollong', from Assam.	8	5·58 lbs. per c. ft. or 8·37 lbs. per M. G. sleeper.	Penetration quite satisfactory.
	V	*Terminalia Manii*, or 'Black Chuglam', from Andamans.	7	1·77 lbs. per c. ft. or 2·65 lbs. per M. G. sleeper.	Absorption probably insufficient to protect the timber.
	VI	*Terminalia, tomentosa* or 'Sain' from Central Provinces.	8	2·125 lbs. per c. ft. or 3·19 lbs. per M. G. sleeper.	Absorption below the mark.
	VII	*Terminalia myriocarpa* or 'Hollock', from Assam.	8	2·87 lbs. per c. ft. or 4·3 lbs. per M. G. sleeper.	Ditto
	VIII	*Pinus longifolia*, or 'Chir', from the United Provinces.	4	4·87 lbs. per c. ft. or 7·3 lbs. per M. G. sleeper.	Absorption satisfactory.

In reviewing the results obtained from these experiments, it must always be borne in mind that the *Rüping* process is an "Open Cell" treatment, so that the amount of oil taken up per sleeper is somewhere about half the amount that would be taken up in the case of a "Full Cell" process. Nevertheless, the amount of oil taken up by the *Dipterocarpus tuberculatus, Terminalia Manii, T. tomentosa* and *T. myriocarpa* sleepers is probably insufficient, and that by *Dipterocarpus turbinatus* hardly sufficient. To make these timbers take up more oil, longer treatment sooner than a high pressure is recommended.

The behaviour of the sleepers treated by this process will be carefully watched as, if successful, it may be of great value to India, where economy in oil is of paramount importance.

(*iii*) TREATMENT OF INDIAN SPECIES OF TIMBER BY THE COMMON OR "FULL CELL" PROCESS.

In 1914, the question of treating certain Andaman *Dipterocarps* came under consideration, and, in order to ascertain whether *Dipterocarpus turbinatus* would lend itself to treatment, no pressure plant existing at that time in India, a batch of sleepers were sent to England to be tested. The work was carried out by Messrs. George Black & Sons, Creosoting

Engineers at Berwick-on-Tweed. The sleepers treated consisted of 50 metre-gauge sleepers and 46 broad gauge sleepers, 3 broad gauge sleepers in addition having been treated after having been cut in half for preliminary experiments. These initial tests with the six half-sized broad gauge sleepers gave the following results :—

TABLE XXX.

No. of specimen.	Weight before treatment, in lbs.	Weight after treatment, in lbs.	Difference in weight, in lbs.	Absorption per cubic foot, in lbs.	Pressure in lbs. per sq. inch.	Duration of treatment, in minutes.	REMARKS.
A 1	99·5	108	9·5	5·8	100	30	Hardly sufficient.
A 2	94·5	105·5	11	6·7	100	30	
B 1	99·5	109·5	10	6·1	125	30	
B 2	95	106	11	6·7	125	30	
C 1	86	98·5	12·5	7·6	150	30	Sufficient.
C 2	87	101·5	14·5	8·8	150	30	

The above trial lot having been treated, in order to ascertain the lines on which the rest should be treated, the other sleepers, referred to above, were all treated at 150 lbs. pressure for 3 hours with the following results :—

TABLE XXXI.

No. of sleepers treated.	Total weight before treatment.			Total weight after treatment.			Difference in weight, in lbs.	Absorption per cubic foot, in lbs.	REMARKS.
	Tons.	cwt.	qrs.	Tons.	cwt.	qrs.			
50 M. G. sleepers.	1	18	3	2	3	3	560	7·5	Sufficient.
46 B. G. sleepers.	4	2	0	4	10	3	980	6·8	It would be well to keep the figure well over 7 lbs. per c. ft. by prolonging the period to 4 hours.

The firm, in their report, state that they split one large and one small sleeper through the middle and found the results satisfactory, creosote being traced right through the sleepers. They also had a portion of the timber taken from the centre of one of the half sleepers analysed and found it contained creosote. From these experiments it is clear that this species of timber presents no difficulty in treatment.

The treated sleepers were returned to India and handed over to the Eastern Bengal State Railway. They were laid in the open line in June 1915 under the following conditions :—

TABLE XXXII.

Record of experimental sleepers treated under pressure by Messrs. George Black & Sons and laid for experimental purposes in the Eastern Bengal State Railway.

Species.	No. of sleepers laid down.	Locality where laid down.	Date of laying down.	Date of last inspection.	Inspection notes.	REMARKS.
Dipterocarpus turbinatus from Andamans.	46 B. G. sleepers.	Between Naihati and Kankinara, Down line mile 22, Telegraph posts Nos. 22/18 to 22/19.	18th June 1916.	23rd June 1917.	None removed up to date. Their condition is as good as the day they were laid in the line, except that slight surface cracks have developed. On the under surface they are perfectly sound. Inspected by Mr. Taylor, Sub-Divisional Officer, and Forest Economist.	D. C. T. cut on top of each sleeper.
Ditto	46 M. G. sleepers.	Between Phulbari and Bhowanipur, mile 101, Telegraph posts Nos. 101/19 and 101/21.	15th August 1915.	January 1917.	The sleepers are in good condition, the rail-seats do not appear to have been damaged and the screw-spikes are all very firm still. The sleepers in appearance are very like Sal sleepers and appear to be as hard. Some of them have developed slight longitudinal cracks, but in this respect also I do not think they are any worse than Sal sleepers. It is impossible to say yet whether they will turn out as good as or better than Sal in the long run. Inspected by the Executive Engineer, Saidpur District.	Z. X. V. stamped on each sleeper.

(*iv*) SLEEPERS OF INDIAN TIMBERS CREOSOTED AT THE INSTIGATION OF MESSRS. MILLAR'S TIMBER AND TRADING CORPORATION.

The writer is indebted to the above firm for the following information. In 1911 Messrs. Millar's Timber and Trading Corporation sent 6 sleepers of *Abies Pindrow* (Silver fir), *Picea Morinda* (Spruce), *Pinus longifolia* (Chir), and *Pinus excelsa* (Kail) to England to be creosoted. The sleepers, after treatment, were returned to India and handed over to North-Western Railway to be laid in the line.

The report of the Engineer, who supervised the treatment on behalf of the firm, states that the creosote employed had a specific gravity 1·070 to 1·076, 75 per cent. distilling over at 610°F., Tar acids 8—10 per cent. The treatment consisted in subjecting the sleepers to a pressure of 95 lbs. per square inch, the temperature of the oil being maintained at 75°C. The results were as follows :—

Species.	Weight per cubic foot, untreated.	Absorption, 2 hours treatment, in lbs. per cubic foot.	Absorption, 6 hours treatment, in lbs. per cubic foot.
	lbs.	lbs.	lbs.
Silver fir	33·3	2·54	3·15
Spruce	30·7	1·58	2·5
Chir pine	47·2	7·32	8·47
Blue pine	34·5	1·01	1·51

On cutting open the sleepers, it was found that, at 6″ and 18″ from the ends, the penetration in the case of 'Silver fir,' 'Spruce' and 'Blue pine' was unsatisfactory and incomplete. The 'Chir' pine, however, showed good absorption, with the whole area impregnated at mid-length.

The sleepers on being returned to India were laid in the line, and the latest information from inspection reports is given below :—

TABLE XXXIII.

Record of experimental sleepers of Indian Timbers, creosoted by Messrs. Millar's Timber and Trading Co., laid down in the North-Western Railway.

Species.	No. of sleepers laid down.	Locality where laid down.	Date of laying down.	Date of last inspection.	Inspection notes.
Abies Pindrow, 'Silver fir.'	6 B.G.	Ranipur Station, mile 261/89 N. W. Railway.	22nd March 1912.	22nd April 1917.	Four having been found heavily damaged by white-ants were removed from the road in December 1916. Two left now are alright. Slight tendency to cut under the bearing-plate.
Picea Morinda, 'Spruce.'	Do.	Do.	Do.	Do.	One was removed previously having badly cracked. Four were removed in December 1916 having been eaten by white-ants, the last now removed badly damaged.
Pinus longifolia, 'Chir.'	Do.	Do.	Do.	9th October 1914.	General condition good. Spikes on bearing-plates holding well. No white-ants. There is a marked tendency to warp ; while the small surface cracks which have appeared are of no account. There is a slight tendency for the bearing-plate to cut into the seat.
Pinus excelsa, 'Kail.'	Do.	Do.	Do.	Do.	Very good condition generally.

The silver fir and spruce have been heavily attacked by white-ants, due no doubt to the very small quantity of oil they absorbed during treatment.

(*v*) RECORD OF CREOPINE SLEEPERS LAID IN THE BENGAL AND NORTH-WESTERN RAILWAY.

In 1906-07, the Bengal and North-Western Railway laid down at mile 27 of the Mansi-Bhaptiahi Extension of their system, a consignment of creosoted pine obtained from Europe. The exact species of pine

which was employed is not known, but it probably came from Norway. In 1912, that is after 6 years, after a careful examination it was found that 34 per cent. of them required almost immediate renewal. The Chief Engineer was in consequence obliged to report adversely upon these sleepers, the cause of rejection being due to a combination of rot, white-ant attack and mechanical wear and tear.

No details are available as to the method of treatment or of the quality of the oil with which the sleepers were injected, which robs the experiment of a great deal of its value.

(*vi*) CONCERNING A LARGE CONSIGNMENT OF CREOSOTED DOUGLAS FIR SLEEPERS FROM BRITISH COLUMBIA PURCHASED BY THE BENGAL AND NORTH-WESTERN RAILWAY COMPANY.

One of the largest consignments of treated sleepers as yet purchased by any Indian Railway, was that of 160,000 creosoted *Douglas Fir* which took place in 1914. Details of this consignment were given by the Chief Forester, Forest Branch (Lands Department), Victoria, British Columbia, in a letter dated 8th October 1914 to the Honorary Editor of the *Indian Forester* and, in order to describe the method of treatment, and the specifications under which these sleepers were to be supplied, we cannot do better than quote the letter *in extenso* :—

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" A cargo of 160,000 creosoted *Douglas Fir* sleepers were recently sent from British Columbia to India. This shipment constitutes a trial order placed in British Columbia, by the Bengal and North-Western Railway Company, for the purpose of testing creosoted *Douglas Fir* sleepers in service in India.

"The specifications governing the grades of timber to be accepted, the grade of oil to be used, and the manner of treatment were furnished by the Bengal and North-Western Railway Company. The important features of the specifications were :—

1. The sleepers were to be of the best quality *Douglas Fir*, well-seasoned, perfectly sound, sawn from logs cut within two years, free from sap-wood, rotten wood, or materially depreciating shakes, wanes and large or loose knots.
2. No waney edges were allowed.
3. The treatment should ensure an absorption of 12 pounds of *creosote* per cubic foot.
4. The *creosote* should conform to the following specifications :—
   Completely liquid at 38°C.
   Specific gravity at 38°C.—1·03.

Only 8 per cent. by volume of tar acids to be soluble in caustic soda solution.

No distillate below 200°C., not over 5 per cent. below 210°C., not over 25 per cent. below 235°C., and the residue 355°C., if it exceeds 5 per cent. in quantity, should be soft.

"The inspection of the timber and of the creosoting operations was carried out by the Provincial Forest Branch. The sleepers were cut from sound *Douglas Fir* logs felled within the preceding twelve months. No sleepers with shakes, splits, loose or large knots sap-wood or defective wood were passed for treatment.

"The sleepers were creosoted immediately after being sawn.

"English oil was used, the specific gravity at 38°C. being 1·04, 13 per cent. by volume of tar acids extracted at 38°C., no distillate at 200°C., 1·2 per cent. at 210°C., 11·2 per cent. at 235°C., and a soft residue comprising 22 per cent. of the total volume remaining at 355°C.

"The sleepers were treated under a pressure process, remaining under pressure for six hours at a temperature of 125°F. and a pressure of 5 lbs. at the beginning of this period, and 180°F. and 85 lbs. at the end of the period. The sleepers were under treatment 30 hours, and in the creosote bath 24 hours.

"The average absorption of creosote per cubic foot was 12·03 lbs. The penetration of oil at the centre of the sleepers averaged over one inch in depth. The penetration from the end of the sleeper parallel to the grain was very much greater.

"The specification did not call for the boring of sleepers for spikes before treatment. The spike holes would greatly increase the penetration of creosote under the rail and strengthen the sleeper against decay at the weakest point, the rail-seat. Should any further trials be made of creosoted *Douglas Fir* sleepers, a point should be made of boring the sleepers before treatment.

"Constant improvements are being made in the method of creosoting *Douglas Fir*. A study of the service rendered by this shipment may indicate further changes to be made in the process of treatment, the quantity of oil used or the grade of wood to be accepted for treatment. A supply of cheap structural timber stands in British Columbia awaiting markets. We know that it can be given a preservative

treatment which will fit for tropical use as railroad sleepers or in structural works. It is only necessary that a study should be made of the requirements of India, in order that British Columbia may be in a position to fill those requirements.

"The sleepers have only been recently laid in the line; so, at present, they tell us nothing, their behaviour in future years will be watched with considerable interest."

(3) Conclusions, based on the above Experiments.

The experiments carried out in India in recent years, with sleepers treated under pressure have, with the exception of a few creosoted sleepers, laid in the North-Western Railway and Creopine laid in the Bengal and North-Western Railway, all been in progress so short a time that no data as to the durability of the sleepers are available. The creosoted 'Silver fir,' 'Spruce,' 'Chir' pine and 'Blue' pine, laid in the line four years ago are in fair condition, while the Creopine have shown a life of six years only, which is not satisfactory.

The Assam experiments show that *Dipterocarpus pilosus* timber treats without any difficulty, but that *Terminalia myriocarpa* will require special treatment even to make it take up 6 lbs. to 8 lbs. of oil and *Bischofia javanica* is obviously difficult to treat under any conditions. Of the sleepers sent to Europe for treatment, *Dipterocarpus turbinatus* from the Andamans, *D. alatus* from Burma, *D. pilosus* from Assam, and *Pinus longifolia* from the United Provinces, all gave excellent results, while *Dipterocarpus tuberculatus* from Burma, *Terminalia Manii* from the Andamans, *T. tomentosa* from the Central Provinces and *T. myriocarpa* from Assam all showed reluctance to take up the oil, and though most of them can probably be dealt with satisfactorily, they will require special treatment to make them take up the required amount of creosote.

A sufficient number of sleepers of these species of timber have now been laid down by the Railways of India, to assure definite data being obtained in years to come as to their value when treated by the various processes described above.

PART VI.

FACTORS GOVERNING THE TREATMENT OF TIMBER.

(1) General.

It is necessary to deal separately with each factor on which the successful treatment of Railway sleepers depends, as they vary widely

one from another, though they are in most cases entirely dependent one on the other; thus the mechanical strength of the timber does not affect the cost of treatment though, unless both fall within the required specification, such an undertaking is doomed to failure. That the treatment of timber is not always a simple matter, has not been sufficiently recognized in this country, and is without doubt one of the causes of failure in the past. In the following chapter it is proposed to deal with each factor separately, with due regard to their bearing one to another.

(2) Species of timber suitable for Railway sleepers, after treatment.

On pages 11 and 12 of Volume III, Part II, of the *Indian Forest Records*, is given a list of timbers, divided into three classes which, it is thought, might be utilized for sleepers after treatment. Further information as to possible supplies of timber has been collected since that list was prepared, while the results of recent experiments have made it possible to add several new species of timber to those previously mentioned. The lists, as they now stand, are as follows :—

I.
Timbers which are most likely to fulfil the necessary requirements.

1. *Dipterocarpus tuberculatus.*
2. ,, *alatus.*
3. ,, *turbinatus.*
4. ,, *pilosus.*
5. *Shorea assamica.*
6. *Terminalia tomentosa.*
7. ,, *myriocarpa.*
8. ,, *Manii.*
9. ,, *paniculata.*
10. *Pinus longifolia.*
11. *Abies Pindrow.*
12. *Picea Morinda.*

II.
The next most likely species to fulfil the necessary requirements.

13. *Altingia excelsa.*
14. *Anthocephalus Cadamba.*
15. *Vateria indica.*
16. *Terminalia Catappa.*
17. ,, *bialata.*
18. *Bischofia javanica.*
19. *Lagerstrœmia microcarpa.*
20. ,, *Flos-Reginæ.*
21. ,, *parviflora.*
22. ,, *tomentosa.*

III.
Possible sleeper woods . . . .

23. *Pinus Khasya.*
24. *Pœciloneuron indicum.*
25. *Albizzia Lebbek.*
26. ,, *odoratissima.*
27. *Hardwickia binata.*
28. *Vitex altissima.*
29. *Callophyllum Inophyllum.*
30. *Dillenia indica.*
31. *Artocarpus Chaplasha.*
32. *Manglietia insignis.*
33. *Cynometra polyandra.*

The most important alteration made to the former list consists in excluding *Pinus excelsa* from the first class, not because the timber is unsuitable, but on account of the demand for this timber for constructional purposes. *Dipterocarpus pilosus, D. turbinatus, Shorea assamica, Terminalia myriocarpa, T. Manii and T. paniculata* have been added to class I, partly on account of the supplies being considerable and also because recent tests have demonstrated the possibility of treating these timbers, while their mechanical strength is sufficient to withstand the wear and tear to which sleepers are subjected. The most noticeable additions to the first class are *Abies Pindrow* and *Picea Morinda*, the 'Silver fir' and 'Spruce,' respectively, the supplies of which from the Punjab forests are very considerable. A point about which doubt might be expressed in classifying these two timbers under list I, is in respect to their mechanical strength and resistance to absorb an antiseptic. In justification of such a classification, it may be said that in strength 'Spruce' equals, if it does not exceed, that of 'Douglas Fir,' which, after treatment, is commonly used in Canada and America for sleepers, while 'Silver fir' is little inferior to that species. As regards treatment, the tests carried out in England, which are corroborated by laboratory tests in India, show these two species to be extremely difficult to treat; on the other hand, 'Douglas Fir' is equally difficult to treat, so there seems little reason to doubt that the special process adopted in treating the latter species may answer equally well with 'Silver fir' and 'Spruce.'

Class II has lost some species at the expense of class I; on the other hand, *Altingia excelsa, Anthocephalus Cadamba, Vateria indica, Terminalia bialata, Mesua ferrea and Dillenia indica* have been added to it.

Class III could, no doubt, be very much increased, consisting as it does, chiefly of timbers which might easily be placed in class I, were they either available in larger quantities or were not already in such demand for other purposes that their market value in some parts of India is already beyond that of sleeper woods.

The above lists have been prepared after taking into consideration the most important factors upon which depends the possibility of using the timber, after treatment, for Railway sleepers. The essentials are (1) that the available supply should be large, (2) that the cost of the timber as a suitable treating plant be not excessive, (3) that the timber be of sufficient strength for the purpose, and (4) that it should yield readily to treatment.

It is not likely that all the timbers mentioned, or even those in class I, will come into use in the near future. It is, however, possible to indicate which of them are likely to receive prior attention, chiefly on account of

the available supply and cheapness of extraction. Thus *Pinus longifolia* sleepers—the 'Chir' pine of the Lower Himalayas—has already been treated in considerable numbers and is being supplied to State Railways. The other more likely sleepers which deserve early attention may be divided into two groups: first, the Andaman timbers including *Dipterocarpus turbinatus, D. alatus, Terminalia Manii, T. bialata, T. Catappa,* and the Himalayan 'Spruce' and 'Silver fir'; and secondly, the Assam species consisting of *Dipterocarpus pilosus, Shorea assamica, Terminalia myriocarpa,* possibly *Altingia excelsa* and others. Any Railway Company or private firm considering the question of treating sleepers, would do well to consider the possibility of starting work in either one or other of these localities. It might with justice be asked why the great variety of fine timbers found in the Burma forests are not included. The reason is that labour is expensive and not over-plentiful in Burma and that most other considerations are at present overshadowed by the trade in teak timber, though there is not the least doubt that Burma stands easily first as regards its future possibilities.

(3) The mechanical strength and seasoning qualities of timbers suitable for sleepers.

(*i*) MECHANICAL PROPERTIES.

From inspections made of the treated sleepers in the line, it seems fairly certain that the timbers of *Pinus longifolia, P. excelsa, Abies Pindrow,* and *Picea Morinda* are not sufficiently tough to withstand the cutting action of the foot-rail, and that they will require to be fitted with bearing-plates.

In the case of the four *Dipterocarps* and *Shorea assamica* mentioned in list I, provided the traffic is light or moderately so and the foot-rail fairly broad, it will probably not be found necessary to use bearing-plates, whereas if the traffic is heavy, they will be necessary.

As regards *Terminalia tomentosa, T. myriocarpa* and *T. Manii,* all of which are hard timbers, it is thought that no bearing-plates will be necessary.

The tendency of the dog-spike to enlarge the spike holes has also to be considered. While inspecting the various lots of treated sleepers, several of the spikes were drawn in order to ascertain whether or not they showed any tendency to shake loose and, in no instance, was this found to be the case. The spikes were found to be holding moderately well in the case of the *Pine* sleepers, well in the case of the *Dipterocarps,* while the *Terminalia tomentosa* sleepers held the spikes so strongly that they could only be removed with difficulty.

The power of certain Indian timbers to withstand a direct pull applied to a dog-spike driven into the sleeper, has recently received attention and tests have been carried out in this connection in the Forest Economist's workshops at Dehra Dun. The machine employed in carrying out these tests is of the usual type used for carrying out tests for transverse, compression and shearing strain, the only alteration necessary being a specially devised clutch to hold the head of the dog-spike. The results obtained are strictly comparable, as they were carried out on similar lines. Some of these results, to illustrate the power of various timbers to withstand spike pull, are given below :—

TABLE XXXIV.

The figures given below are average of four tests in each case.

Species.	Method of driving spikes.	Direct pull in lbs., required to withdraw dog-spikes, being the average of 4 tests.	REMARKS.
Cedrus Deodara .	Hole bored $\frac{3}{8}''$ right through sleeper and spike driven home.	4,315	Spikes released suddenly.
Ditto	Hole bored $\frac{1}{2}''$ right through sleeper and spike driven home.	3,791	In some cases the spikes released suddenly, in others slowly.
Ditto .	Hole bored $\frac{5}{8}''$ right through sleeper and spike driven home.	2,770	Spike released somewhat slowly.
Ditto .	Hole bored $1\frac{1}{2}''$ deep with $\frac{3}{8}''$ augur and spike driven home.	3,807	Spikes released suddenly.
Ditto .	Hole bored $1\frac{1}{2}''$ deep with $\frac{1}{2}''$ augur and spike driven home.	3,959	Ditto
Ditto .	Hole bored $1\frac{1}{2}''$ deep with $\frac{5}{8}''$ augur and spike driven home.	3,709	Spikes released somewhat slowly.
Shorea robusta .	Hole bored $\frac{3}{8}''$ right through the sleeper and spike driven home.	5,315	In one case spike released somewhat slowly. In other cases spikes released suddenly.
Ditto .	Hole bored $\frac{1}{2}''$ right through the sleeper and spike driven home.	5,352	In one case spike released suddenly. In other cases spikes released somewhat slowly.

TABLE XXXIV—*contd.*

The figures given below are average of four tests in each case—contd.

Species.	Method of driving spikes.	Direct pull in lbs., required to withdraw dog-spikes, being the average of 4 tests.	REMARKS.
Shorea robusta .	Hole bored ⅝″ right through the sleeper and spike driven home.	5,155	Spikes released somewhat slowly.
Ditto .	Hole bored 1½″ deep with ⅜″ augur and spike driven home.	4,366	In one case spikes released suddenly. In other cases spikes released somewhat slowly.
Ditto .	Hole bored 1½″ deep with ½″ augur and spike driven home.	4,156	Ditto
Ditto .	Hole bored 1½″ deep with ⅝″ augur and spike driven home.	3,869	Spikes released somewhat slowly.
Pinus longifolia or 'Chir' *Powellized* old sleeper, having been 3 years in the line.	Hole bored ½″ through sleeper, and spike driven home.	3.038	The spike released slowly.
Dipterocarpus alatus	Hole bored ⅜″ and 1½″ deep, spike driven home.	8,210	Spike released slowly.
Ditto	½″ hole bored through sleeper and spike driven home.	6,202	Ditto
Ditto	⅝″ hole bored through sleeper and spike driven home.	5,587	Ditto
Dipterocarpus tuberculatus.	Hole bored ⅜″ and 1½″ deep, spike driven home.	8,315	Spike released suddenly.
Ditto	⅝″ hole bored through sleeper and spike driven home.	8,345	Spike released slowly.
Ditto	Ditto	6,765	Ditto
Dipterocarpus pilosus.	Hole bored ⅜″ and 1½″ deep, spike driven home.	6,870	Ditto
Ditto	½″ hole bored through sleeper and spike driven home.	5,575	Ditto
Ditto	⅝″ hole bored through sleeper and spike driven home.	5,030	Ditto
Silver fir . .	No hole bored previous to driving spike.	1,993	Ditto
Spruce . . .	Ditto	2,477	Ditto

(*ii*) SEASONING OF SLEEPER WOODS.

(*a*) *General discussion of the subject.*

It is difficult to lay sufficient stress on the importance of seasoning timber before treatment, for unless proper care is taken in this respect any undertaking of this nature will be doomed to failure. In making the above very definite statement, such processes as *Haskinizing* must be excluded as, in this process, the saps in the timber are sterilized and made use of for preserving the fibre. The reasons for only using seasoned timber for treatment are that (*i*) the inclusion of large quantities of moisture in the timber, by partial impregnation of the fibre, results in the premature decay of the tissue ; (*ii*) the smaller the amount of sap and nutritious substances left in the timber, the less liable is it to fungus and insect attack ; (*iii*) the impregnation of the timber with an antiseptic in *Open Tanks* and to a somewhat less extent when treated under *Pressure*, becomes in direct proportion more difficult as the percentage of moisture in the timber increases ; (*iv*) unseasoned timber is liable to develop cracks owing to the rapidity of seasoning when placed in the line ; this is a factor of paramount importance in the case of Indian timbers, exposed to Indian conditions of climate ; and lastly, (*v*) that seasoned timber, even in an untreated state, lasts longer than unseasoned timber.

The second point raised is a corollary of the first, and they both concern decay. For decay to take place in timber, moisture, air, light and warmth are necessary. Provided the timber does not crack, moisture and air are excluded from the outer surface of a sleeper by the shell of treated tissue. As soon as a fine crack penetrates through the outside layer of treated timber, air and light are admitted and provided the internal layers of timber in the sleepers still contain much moisture, the conditions necessary to fungus growth are present, hence the necessity for seasoning the timber before treatment.

The third point refers to penetration of the antiseptic. That an oil or salt will penetrate seasoned timber more readily than unseasoned timber is fairly obvious ; for, in the former state, the cells are more open than when filled with sap. In practice, if a piece of timber is treated green, on being cut open it will be seen that the distribution of the antiseptic oil is in streaks or patches and in any case is very irregular, due to the presence of moisture which has stopped penetration in places and not in others, whereas if the wood be seasoned the penetration is deeper and much more uniform.

The next point refers to the liability of unseasoned timber to crack to a greater extent than does seasoned timber. This is a most important

point, as not only has it been found necessary to prematurely reject many sleepers after they have been in the line a short time, due to excessive cracking, but in many cases the conversion of sleepers from green logs has resulted in excessive splitting, resulting in rejection before treatment. As an example in point, it may be stated that some of the *Dipterocarp* sleepers prepared in Burma and destined for experimental purposes, were cut from green logs, resulting in upwards of 70 per cent. rejections before treatment, whereas those prepared afterwards to make up the deficit were cut from seasoned logs, of which not 4 per cent. had to be rejected.

A further lesson in connection with the splitting of timber can be learnt by examining the experimental sleepers treated with different antiseptics, which have been laid down in the line during the last six years. It only requires a superficial inspection of any of these sleepers, and especially of those which have been for upwards of 6 years in the line, to see that the treatment has, in nearly every instance, protected the fibre from decay and that the real danger, when it exists, is due to excessive cracking. Some of these sleepers were very thoroughly seasoned, others only partially so, as at the time that the experiments were carried out, the importance of employing only thoroughly seasoned timber was not fully realized.

(b) *Percentage of moisture in timber.*

This brings us to the question of the percentage of moisture in the timber, that is, to a definition of what is meant by "air-dry" timber. In Europe and in the temperate climate of North America, where the minimum percentage of humidity in the air is considerably in excess of the minimum in the dry zones of India and where the temperature is far below that of the Peninsula or of Northern India, air-dried timber contains anything from 15 per cent. to 30 per cent. of moisture. In the hot weather, in the dry zones of India, seasoned timber contains from 8 per cent. to 15 per cent. of moisture, according to the species. In the damper climates, such as exist in parts of Burma, Assam, Bengal and the West Coast, seasoned timber rarely contains less than 18 per cent. to 25 per cent. of moisture. Thus, the experimental *Dipterocarpus pilosus* sleepers, dealt with in the Digboi experiments, which were treated 2 years after conversion, contained as much as 27 per cent. of moisture, for the reason that Assam possesses a damp climate. On the other hand, when testing timber at Dehra Dun, which has a fairly dry climate for 7 months of the year, with a temperature rising to 105°F. in May and June, no tests are carried out unless the timber contains under 15 per

cent. of moisture. In Central India, the Punjab and Rajputana, where temperatures run high and the moisture in the air is very low during the dry season, the percentage of moisture in timber falls below 10 per cent. It is therefore impossible to lay down a hard and fast rule as to what should be considered to be "air-dry timber." Provisionally, it may be laid down that sleepers destined to be placed in dry, hot localities should not be treated if containing more than 15 per cent. of moisture and in wet localities not more than 25 per cent. of moisture.

By accepting the principle that timber must be seasoned to a point commensurate with the degree of moisture and heat to which it will be subjected after treatment, the question of how best to season the timber must be considered. In the dry zone areas of India, there is generally no difficulty whatsoever in reducing the moisture in timber below 15 per cent.; on the other hand, the process of seasoning is often so rapid that serious cracks develop in the timber, and it is only by protecting the timber from the direct rays of the sun that such defects can be reduced to a minimum. It is in the damper localities, such as the West Coast, parts of Bengal and Burma, in Assam, and in the Andamans that special measures may have to be taken to reduce the percentage of moisture in the timber and to hasten the process of seasoning. Natural seasoning in such localities will hardly reduce the moisture in the timber to 25 per cent., except perhaps for a short period during the hot weather. The prevailing conditions, therefore, point to the necessity for artificial seasoning of the timber. This is generally a somewhat costly process, and one which requires a certain amount of skill. Many patent plants exist which have been designed for seasoning timber such as, for instance, the Sturtevant or Erith's processes. It is thought that to season sleeper woods entirely in such plants would not be practicable, as the amount of timber to be handled would be very considerable, though it may be found profitable to use such plants to finish off the seasoning process, after natural seasoning has reduced the moisture in the sleeper as far as is possible.

(c) *Steam, Vacuum and Oil seasoning experiments.*

In Europe and America, and especially in the latter continent, timber is sometimes seasoned either with the help of steam and vacuum or by boiling in oil. To ascertain to what degree of dryness certain Assam species of timber could be seasoned by these methods, the writer carried out experiments in February 1916, at Digboi, in the same treating cylinder as was used the previous year for treating the sleepers. Details of

the methods employed in carrying out these experiments are given below :—

Experiment I.—Steam and Vacuum seasoning.

This experiment was carried out with the object of determining whether absolutely green sleepers of Hollong (*Dipterocarpus pilosus*), could be seasoned by hot steam, as described in Weiss's work on timber treatment.

The experiment was carried out in the plant referred to previously. The procedure followed was to charge the cylinder with four absolutely green "Hollong" sleepers, which were weighed before being treated. The sleepers were subjected to live damp steam for 2 hours, the temperature being gradually raised by the heating coil to 230°F., the pressure at that time being 10 lbs. After this the steam was cut and a vacuum corresponding to a column of 20 inches of mercury was applied for ½ hour, the temperature being lowered to 190°F. During this process a certain amount of sap was extracted, but as the sleepers had only lost an average of 3·25 lbs. each, it was decided to continue the process on more drastic lines. They were therefore again put into the cylinder, and subjected to a further bath of live steam for 4 hours, at 20 lbs. pressure, and a temperature of 250°F. After this a vacuum of 20 inches was applied for ¾ hour, the temperature being 187°F. The results are summarized below :—

TABLE XXXV.

Sleeper No.	Weight before treatment, in lbs.	Weight after treatment, in lbs.	Loss of weight, in lbs.	Total duration of steaming.	Maximum temperature.	Maximum pressure.	Total duration of vacuum.	Maximum vacuum.	Maximum temperature, during vacuum.
V	90	81·0	9·0	6 hours.	250°F.	20 lbs.	1¼ hours.	20"	187°F.
VI	107·5	95·5	12·0						
VII	90	81·5	8·5						
VIII	94	84	10·0						
Average	95·4	85·5	9·9						

The sleepers treated were of metre-gauge size and therefore contained 1·5 cubic feet of timber, a cubic foot of which weighed 63·6 lbs. green and 57 lbs. after steam-seasoning. Gamble gives the weight of air-dried 'Hollong' as 43 lbs. per cubic foot; steam-seasoning, therefore,

had only reduced the amount of moisture in the timber to about one-third the necessary amount. The sleepers were examined after treatment and were found to have developed numerous small surface cracks. On examination of the interior of the timber the tissue was found to be quite wet, though the pores, which are large and numerous in this species, were free from sap on the end section.

Experiment II.—Oil-seasoning.

The same plant, with the addition of a condenser pipe, was used in carrying out the oil-seasoning experiment. The cylinder was charged with metre-gauge 'Hollong' sleepers, in an absolutely green state. Hot oil was run into the cylinder, leaving a vacant space at the top, though submerging the sleepers. The heating coil was started at 9 A.M. and the oil gradually raised to 223°F. by 1 P.M., by which time 1¾ gallons of sap had distilled over. By 4 P.M., that is, 7 hours after heating commenced, 4¾ gallons of sap had been collected. As, by this time, the condenser flow was much reduced, the heating operation was stopped, the cylinder was filled with oil and a pressure of 15 lbs. applied for 15 minutes. When running off the oil it was found that a little over 2 gallons of sap had collected in the cylinder, due to condensation of the vapours against the inside top of the cylinder. It might be contended that this was not sap, but as no live steam had been introduced, while the amount of water in suspension in the oil could also not possibly account for more than a pint at most, it is certain that this accumulation could be nothing but condensed sap. It is therefore necessary to add these two gallons, so collected, to the 4¾ gallons collected from the condenser pipe, in all 6¾ gallons.

The results may be summarized as follows :—

TABLE XXXVI.

Sleeper No.	Weight before treatment, in lbs.	Weight after treatment, in lbs.	Difference, in lbs.	Heating period.	Amount of sap collected.	Duration of pressure.	Pressure applied.
I	98·5	99	+0·5	7 hours.	6¾ gallons.	15 minutes.	15 lbs.
II	96	100	+4·0				
III	101	100	—1·0				
IV	94	97	+3·0				
TOTAL .	389·5	396	+6·5				
AVERAGE	97·4	99	+1·6				

From the above statement it will be seen that the four sleepers have increased in weight by 6½ lbs., while they have lost 67½ lbs. of sap, assuming that the specific gravity of sap is 1. The amount of oil, therefore, which they have absorbed is 74 lbs. or 18·5 lbs. per sleeper. The average weight of a green sleeper was 97·4 lbs.; deducting 1·69 gallons of sap lost by one sleeper during treatment, its weight would be 80·5 lbs., leaving out of consideration the amount of oil absorbed. As a metre-gauge sleeper is 1·5 cubic feet, the weight per cubic foot after treatment amounts to 53·6 lbs., while air-dried 'Hollong' weighs 43 lbs. per cubic foot. To complete the seasoning of the sleepers it would, therefore, be necessary to take out another gallon of sap per c. ft. The sleepers were examined and found to be not cracked after treatment.

Conclusions.

Taking into consideration that the above experiments were only carried out with relatively few sleepers, they are not final. Provisionally, the following conclusions have been arrived at :—

1. That partial seasoning can be obtained by either steam or oil seasoning, but that the process is in both cases incomplete.
2. That oil seasoning gives better results than steam seasoning as, by the former process, the four sleepers lost a total of 39·6 lbs., while those treated in hot oil lost 67·5 lbs. by weight.
3. That were the oil seasoning process to be prolonged at a slightly higher temperature, the point of seasoning reached might be sufficient for sleepers used in the damp climate of Assam, but not for dry hot situations.
4. That the above experiments having been carried out on a very small scale, they cannot in any way be accepted as final.

From what has been said above, it will be gathered that there are two possible ways of dealing with the question of seasoning timber before treatment in damp climates : (*i*) to naturally season as far as possible and finish off the process in drying kilns, or (*ii*) to season in oil in conjunction with treatment. Until further data are available, no definite statement can be made as to the relative merits of these two processes when working under Indian conditions, though probably the former process would be the safer of the two to adopt under existing circumstances.

(4) Discussion as to the most suitable method of treating timbers.

When considering the best method to be adopted for the treatment of timber, we have first to take into consideration the species of timber

to be treated, the size and shape of the timber and the quantity to be dealt with. On these three factors will depend whether we adopt the *Brush, Open Tank* or *Pressure* processes. When a relatively small quantity of timber, say, for instance, a few hundred fencing posts, or constructional timber for a small bungalow has to be handled, application of two or more coatings of the antiseptic with a brush may suffice. In the event of a larger number of posts, telegraph poles, bridging or constructional material or from 30,000 to 50,000 sleepers having to be treated, the timber of which readily absorbs an antiseptic, an *Open Tank* plant may best answer the purpose; while, for large quantities of sleepers, the timber of which does not readily absorb the antiseptic and where the plant is of a permanent nature, a pressure plant is advocated.

The amount of the antiseptic to be introduced also requires consideration when deciding between *Open Tank* and *Pressure plants*; thus, if 6 lbs. or more per cubic foot is the amount specified, unless the timber is especially absorbent, a Pressure plant will be required.

(5) Choice of Antiseptics.

With a view of determining the most suitable antiseptic for general use in India, the experiments detailed in Parts III, IV and V have been started. The choice of treatment may be said to lie between (*i*) *Powellizing*, (*ii*) *Coal-Tar creosotes*, patent or otherwise, (*iii*) mixed *Coal-tar creosotes* and *Petroleum* products, (*iv*) *Salts*, such as *Chloride of Zinc*, *Atlas*, *Fluoride* solutions, *Copper Sulphate*, etc., and (*v*) mixed impregnation, first with a *salt* and then with a *creosote* oil.

(*i*) POWELLIZING.

In favour of *Powellizing*, we have experiments which have now been in progress for over six years, yielding satisfactory results. It is understood that, in Australia, *Powellizing* has been introduced in recent years, with the object of thoroughly testing its value for preserving Railway sleepers. Taking these facts into consideration, the writer is strongly in favour of following the lead given by the Australian Engineers and of giving this process an extensive trial in India.

(*ii*) COAL-TAR CREOSOTES.

Without doubt, *Coal-tar creosotes* are excellent preservative agents for timber, as they have withstood the test of time and still hold their own against almost all other solutions. Such an assertion requires qualification, in as much as all *Coal-tar creosotes* are not suitable for

treating timber: the suitability or otherwise of the oil is dependent on its composition. Some *creosotes* contain more tar acids than others, while others contain an excess of *crésolic* and *phénolic* substances which, though of a highly antiseptic nature, are too volatile to be used in the treatment of railway sleepers. Thus not more than 8 per cent. of tar acid should be present, while the oil used should commence to boil at about 205°C. and contain a predominance of Napthaline oils, boiling up to 250°C. and the remaining Anthracene oils boiling up to 360°C. and over.

Various specifications have been laid down by Experts, Railway Companies and Timber Treating Associations from time to time, a few of which, together with the analyses of the oils used in the experiments described in the previous chapters, are given below, which may help interested persons in their choice of a suitable oil :—

TABLE XXXVII.

ANALYSIS CARRIED OUT BY DR. FRANK.		BY MR. PURAN SINGH, CHEMICAL ADVISER, FOREST RESEARCH INSTITUTE.			
Name of Antiseptic.	*Green oil.*	*Avenarius Carbolineum*	*Solignum.*	*Liquid Fuel.*	*Avenarius Carbolineum* and *Liquid Fuel* oils mixed in equal proportions.
Specific gravity at 15°C.	1·096	1·130	1·095	at 30°C.—0·848	
Water	a trace only	1·40 per cent.	1·10 per cent.	2·65 per cent.	not recorded.
Solids at 15°C.	*Nil.*	0·92 ,,	0·43 ,,	at 30°C. 0·59 per cent.	
Tar acids	5 per cent.	1·51 ,,	3·35 ,,	0·08 per cent.	
No. of drops coming over at 160°C.	*Nil*	1st drop	*Nil*	*Nil*	*Nil.*
Ditto 180°C.	,,	*Nil*	1st drop	1st drop at 185°C.	,,
Ditto 200°C.	,,	,,	(not recorded)	(not recorded)	,,
Ditto 210°C.	,,	3rd drop	21st drop	12th drop	1st drop.
	1st drop at 221°C.				
Ditto 230°C.	3rd drop	7th ,,	62nd ,,	29th ,,	3rd ,,
Ditto 250°C.	11th ,,	17th ,,	143rd ,,	52nd ,,	16th ,,
Ditto 270°C.	30th ,,	21st ,,	218th ,,	109th ,,	40th ,,
Ditto 300°C.	51st ,,	48th ,,	357th ,,	203rd ,,	125th ,,
Ditto 320°C.	63rd ,,	(not recorded)	(not recorded)	(not recorded)	(not recorded)
Ditto 360°C.	88th ,,	Do.	Do.	Do.	Do.

By examining these analyses it will be seen that *Green oil*, which is a commercial *Coal-tar* creosote, fulfills all the conditions necessary for a

good antiseptic solution. It commences to boil at 221°C. and contains oil boiling at over 360°C. and therefore contains no *Phénol* or *Crésol* oils, which is probably an advantage when considering oils for use in the hot climate prevailing in India. *Avenarius Carbolineum* oil contains even higher boiling point oils than *Green oil*, as only 48 drops of the former against 51 drops of the latter, passed over at 300°C. *Green oil*, on the other hand, contains 5 per cent. of acids against 1·51 per cent. in *Avenarius Carbolineum.*

Solignum contains a high percentage of lighter oils, probably of a *Phénolic* and *Crésolic* character and is therefore highly antiseptic. It also contains a fair proportion of heavy oils, for at least half the oil tested remained in the flask after the temperature had been raised to over 300°C.

The *Liquid Fuel* oil shows relatively lower boiling points than *Coal-tar creosotes* which, together with their low toxic value, would probably debar it from being used unmixed with a creosote oil.

The mixture of *Avenarius Carbolineum* and *Liquid Fuel* gives a quite satisfactory analysis, indicating that the mixture may be of great value for treating timber under Indian conditions, especially as it reduces the cost of the solution, thus either permitting greater quantities of the oil being used or, if that is not desired, considerably reducing the cost of treatment.

The analyses given above are for oils used in the experiments carried out and described in Parts III, IV and V; below are given some standard specifications, fixed for creosote oils used in Europe and America.

The following is the specification for creosote oil fixed by the London North-Western Railway :—

18	per cent. between	205°C. and 245°C.
12	,, ,,	245°C. and 270°C.
22	,, ,,	270°C. and 320°C.
15	,, ,,	320°C. and 420°C.
33	,, residue above	420°C.

Elsewhere in this note reference has been made to 160,000 creosoted *Douglas Fir* sleepers being imported into India from British Columbia. The creosote to be used was to conform to the following specifications :—

(1) Completely liquid at 38°C.

(2) Specific Gravity at 38°C.—1·03.

(3) Only 8 per cent. by volume of tar acids to be soluble in a Caustic Soda solution.

(4) No distillate below 200°C., not over 5 per cent. below 210°C., not over 25 per cent. below 235°C., and the residue above 355°C., if it exceeds 5 per cent. in quantity, should be soft.

The oil actually used had a specific gravity 1·04 at 38°C., 13 per cent. by volume of Tar acids extracted at 38°C., no distillate at 200°C., 1·2 per cent. at 210°C., 11·2 per cent. at 235°C., and a soft residue comprising 22 per cent. of the total volume remaining at 355°C. This specification is the one adopted for grade I oil by the American Railway Engineers Association.

Grade II oil, as specified by the Association, is similar to the above, with the following modifications that 8 per cent. is allowed to come over below 210°C., and not more than 35 per cent. below 235°C.

The United States Department of Agriculture, Forest Service, Circular 112, by Messrs. A. L. Dean and E. Bateman, entitled "The Analysis and grading of creosotes," gives the analysis of an A grade oil, which is well adapted for *Open Tank* treatment, where excessive loss from volatilization is possible during the process. It runs as follows*:—

Percentage of distillate.	*Temperature ranges.*
Nil to 2 per cent. from	200°C. to 230°C.
10 " "	218°C. to 240°C.
20 " "	225°C. to 260°C
30 " "	230°C. to 289°C.
40 " "	238°C. to 311°C.
50 " "	257°C. to 326°C.
60 " "	285°C. to 340°C.
70 " "	306°C. to 354°C.

The remainder as residue.

The above are the maximum and minimum percentages permissible in A grade oil. Taking an average of these extremes, a high grade creosote oil would be obtained, with boiling fractions, as given below :—

	Per cent.
Distilling at 210°C.	*Nil*
" " 220°C.	5
" " 230°C.	10
" " 240°C.	15
" " 250°C.	23
" " 260°C.	30
" " 270°C.	37
" " 280°C.	43
" " 290°C.	47
" " 300°C.	50
" " 310°C.	55
" " 320°C.	60
" " 360°C.	80

* NOTE.—These figures are given in diagrammatic form in the above quoted publication

(*iii*) MIXED COAL TAR CREOSOTE AND PETROLEUM PRODUCTS.

We have to consider the possibility of mixing a *Coal-tar creosote* with a cheap *mineral oil*, such as is obtained by rectifying Burma, Assam or Persian earth oils, from which Kerosine oil is prepared. Such oils are very considerably cheaper than *Coal-tar creosotes*, so that in the event of the sleepers which have been treated with mixtures of *Coal-tar creosotes* and *Petroleum* oils proving satisfactory, an important advance will have been made in the solution of the problem of treating railway sleepers in India. The functions of *mineral oils* are to distribute the more toxic oils, to act as a water-proofing agent to the timber and to either reduce the cost of treatment or to allow of more oil being injected into the timber.

(*iv*) SALT SOLUTIONS.

The two salts most commonly used in the impregnation of timber are *Chloride of Zinc* and *Copper Sulphate*. Of these, the former has stood the test of time, being still used in a few impregnating plants in America and, to a still greater extent, on the continent of Europe. Recently, soluble fluorides have attracted a considerable amount of attention in America and Austria, while experiments on a laboratory scale have been carried out with them in India. *Arsenic* is another substance which has been used, being an ingredient both in the *Powell* and *Atlas* processes. The reason for not giving pure salts greater attention in India will be explained in the next paragraph.

(*v*) MIXED IMPREGNATION WITH SALT SOLUTIONS AND COAL-TAR CREOSOTES COMBINED.

The last group of antiseptics contain salt solutions such as *Chloride of Zinc*, *Sodium Fluoride*, *Copper Sulphate*, *Atlas* (a patent arsenic solution) and a variety of others which, as has been stated elsewhere, are not considered suitable for the treatment of timber in localities where moisture is in excess, owing to the liability of the salts to be prematurely leached out of the timber. This brings us at once to mixed impregnation, first with a salt and then with an oil, or to mixing the salt and oil together and to treat the timber simultaneously with both preservatives. As a recommendation for this method of treatment, it has the great advantage that it is cheap as, by treating timber with 10 lbs. per cubic foot of a 2 per cent. solution of *Chloride of Zinc*, the cost does not exceed 2 annas 6 pies per broad gauge sleeper, while the quantity of oil with which it is necessary to treat the sleeper amounts to under half that which would

be necessary were it not first treated with the salt. This method of treatment is solely carried out with the object of reducing the cost and it is in no way claimed for it that it will render the timber more durable than would be the case were it subjected to a more drastic creosote treatment.

(6) Cost of Treatment.

The cost of treating a sleeper with an oil or salt will depend on (*a*) the power of absorption of the timber, (*b*) the amount of antiseptic necessary to protect the timber for a desired period and (*c*) the cost of the antiseptic, handling charges and plant.

(*i*) ABSORPTION.

The degree of penetration of an antispetic depends on the method of treatment, the density of the timber, the arrangement and size of the pores, the percentage of sap-wood to heart-wood, and the percentage of moisture in the timber. Thus greater absorption can generally be obtained in *Pressure* plants than in *Open Tanks*, though the period of immersion is a more important factor than pressure. For instance, better penetration is produced by a long period of immersion at a relatively low pressure than by a short immersion period at high pressure. Again, penetration does not take place laterally to the same extent as it does along the fibre. In conifer woods, the border pits allow of some lateral penetration taking place, especially from the distributing centres formed by dry resin ducts ; in no case, however, do the medullary rays allow of lateral penetration. Large pores are of great use in distributing the antiseptic, a condition that makes it possible to treat dense hard-woods, such as *Terminalia tomentosa*. In the case of straight-grained timbers containing large wood-vessels, such as occur in *Dipterocarpus pilosus* and *D. tuberculatus*, treatment presents no difficulties, due to the inward flow of the antiseptic down the large pores. *Pinus longifolia* timber is equally easy to treat, not on account of the pores, which are absent but to the presence of large resin ducts in the timber. *Spruce* and *Silver Fir*, on the other hand, are refractory to treatment, due to the absence of distributing channels.

Another important factor which governs the amount of absorption, is the percentage of sap-wood to heart-wood in any given sleeper. Not infrequently, sleepers contain some of both, and the former, if dry,

absorbs the antiseptic solution more readily than the latter, resulting in varying depths of impregnation in the timber. This should be avoided, as far as possible, as it may result in an unnecessary amount of the oil or salt entering into one portion of the sleeper and an insufficient saturation of other portions of the fibre. To overcome this difficulty, the United Provinces Authorities divide their sleepers into two classes, namely, (*i*) those containing ⅓rd or more of sap-wood and (*ii*) those containing less than ⅓rd of sap-wood, each class being treated separately.

The other factor governing the absorption of an antiseptic is the percentage of moisture in the timber: this point has already been dealt with under "Seasoning of Timber." In this connection it is interesting to note that green timber absorbs the solution much more slowly than does seasoned timber, while the maximum capacity of absorption of quite green wood is barely half that of seasoned timber.

(*ii*) THE AMOUNT OF ANTISEPTIC NECESSARY TO PRESERVE THE TIMBER.

The quantity of an antiseptic with which it is necessary to impregnate timber, will depend on the use for which the timber is intended. Thus, piles destined for marine work, or telegraph poles to be placed in marshy ground should be treated "to refusal" which, in the case of conifer timber, containing much sap-wood, may amount to 15 lbs. to 20 lbs. per cubic foot. The amount of creosote required for sleeper treatment will vary from 5 lbs. to 10 lbs. per cubic foot, according to the class of timber dealt with. For instance, the *Pinus longifolia* sleepers, which are being treated by the United Provinces Forest Department, are being given 5 lbs. per cubic foot, this being considered enough to protect the sleepers sufficiently long to ensure their being rejected for mechanical defects before the fibre is destroyed by fungus or white-ants. On the other hand, when dealing with the *Dipterocarp* sleepers, the timber of which is much superior to that of *Pinus longifolia*, 7 lbs. to 8 lbs. per cubic foot is advocated; while *Terminalia tomentosa*, which is again superior for sleeper purposes to the *Dipterocarp* timber, should be treated to refusal.

To obtain the above results, *Open Tanks* can generally be used if the amount of absorption does not exceed 4 lbs. or 5 lbs. per cubic foot, and the number of sleepers to be treated does not exceed 30,000 to 50,000; but, for heavier impregnation or where larger numbers of sleepers are involved, Pressure plants should be employed.

(*iii*) Cost of the Antiseptic, handling charges and plant.

Throughout this enquiry it will be seen that every endeavour has been made to ascertain ways and means of reducing the cost of treatment, because *Coal-tar creosote*, not being at present produced in this country, has to be imported and is therefore expensive. When the enquiry was commenced, the line taken was to reduce the amount of oil employed; and, though the sleepers treated with small quantities of *Avenarius Carbolineum* oil are so far doing well, the solution to the problem probably does not lie in that direction. The other methods which are being tried are either to use a large quantity of a cheap salt of recognized value and to protect it with a coating of *Coal-tar creosote* oil, or to use a mixture of *Coal-tar creosote* and *Petroleum* oil.

A point which has so far not been touched on is the possibility of producing a good, though relatively cheap, *Coal-tar* creosote from Indian coal. Were it possible to do so, India would at once be put on an equal footing with Europe and America as regards the treatment of timber. There can be no doubt that were cheap creosote available, not only would the Railways benefit greatly by being able to procure serviceable sleepers in large quantities, but that the Forest Department would be in a position to utilize many of its so-called "inferior timbers," while a new industry would spring up by the manufacture of *Coal-tar creosotes.* An enterprising Calcutta firm has the business of producing *Coal-tar creosote* under consideration: they have already produced a fair grade of creosote, on which they are now working to bring it up to specification. Considering the question from a general standpoint, there should be no difficulty in profitably producing *Coal-tar creosote* oils in India, in view of the fact that at least three, if not four, large concerns are producing tar in coke ovens. Up to date *Coal-tar* has realized high prices in India, but as the tar market is likely to be flooded on the expansion of the industry, the natural outlet for the surplus tar would be the manufacture of *Coal-tar* creosote.

It is of interest to examine the actual figures arrived at by treating experimental sleepers, as described in the previous chapters. While doing so, it must be remembered that owing to the temporary nature of the work, the labour charges were excessive, while unnecessary expenditure was incurred owing to mistakes or unforeseen difficulties. Nevertheless, an examination of the figures arrived at are instructive as denoting a maximum figure of cost, and therefore, in the event of the cost price falling within working limits, clearly indicating the commercial possibility of such an undertaking.

TABLE XXXVIII.

Estimated cost of treating sleepers based on the experiments described in Chapters III and IV, exclusive of cost of extraction and of Royalty on the timber.

Species.	Locality from whence procured.	*Powellized* sleepers.	*Avenarius Carbolineum*	*Chloride of Zinc* and *Green* oil.	*Solignum* and *Liquid Fuel* oil.	REMARKS.
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	
Pinus longifolia.	Chakrata Division, United Provinces.	1 1 0 per B. G. sleeper.	0 12 4 per B. G. sleeper.	1 1 4 per B. G. sleeper.	1 5 0 per B. G. sleeper.	40 per cent. *Solignum* and 60 per cent. *Liquid Fuel* oil.
Pinus excelsa	Ditto	Do.	Do.	Do.		
Dipterocarpus tuberculatus.	Pyinmana Division, Upper Burma.	1 3 0 per B. G. sleeper.	0 7 3 per M. G. sleeper.	0 9 0 per M. G. sleeper.	0 14 10 per M. G. sleeper.	33 per cent. *Solignum* and 67 per cent. *Liquid Fuel* oil.
Dipterocarpus alatus.	Ditto	Do.	Do.	Do.	Do.	Ditto
Terminalia tomentosa.	North Kanara, Bombay; those treated with *Chloride of Zinc* and *Green oil*, from Betul Division, Central Provinces.	1 2 3 per B. G. sleeper.	0 9 5 per M. G. sleeper.	1 0 2 per B. G. sleeper	1 3 8 per B. G. sleeper.	....

From the above table it will be seen that the cost of treating broad gauge sleepers by the *Powell* process varied between Re. 1-1-0 to Re. 1-3-0. The treatment of broad gauge sleepers with *Avenarius Carbolineum*, as carried out in these experiments, was extremely cheap, in spite of the oil costing as much as Re. 1-12-0 per gallon. The cost of treating broad gauge sleepers with *Chloride of Zinc* and *Green oil* varied between Re. 1-0-2 and Re. 1-1-4. This is, in practice, probably the cheapest method of all by which timber can be treated; for, though the figures given in the accompanying table do not substantiate this assertion, the amount of antiseptic introduced into the timber under these experiments was in considerable excess of that in all the other experiments. The cost of treating broad guage sleepers with a mixture of *Solignum* and *Green oil* was relatively high, in spite of the proportion of the more expensive oil being reduced to 33 per cent., the reason being obviously the high cost of *Solignum.* On the other hand, were a good grade of *Creosote* to be substituted for this oil and mixed with a cheap *Petroleum* oil, the cost of treatment could be considerably reduced. This procedure has been adopted in treating the United Provinces 'Chir' sleepers though, in this instance, the amount of oil to be absorbed per sleeper has been raised to 15 lbs., involving a corresponding rise in the cost of treatment. From experience gained in recent years, it is thought that any treatment which involves a maximum cost of more than Re. 1-4-0 to Re. 1-6-0 per

broad gauge sleeper is doubtfully sound, unless either the sleepers can be supplied at the treating plant at an extremely low cost, or the purchasers are willing to pay for the extra amount of oil introduced into the timber.

PART VII.

GENERAL DISCUSSION ON THE TREATMENT OF TIMBER IN INDIA.

(1) The treatment of timber other than sleepers.

Owing to the ravages of white-ants, and to the premature decay of timber in India, when used in construction as posts, telegraph poles, for weirs and bridge work, etc., attempts have, from time to time, been made to protect the timber by artificial means though, in this connection, we are far behind other countries. Enquiries have been repeatedly made by officers of the Public Works Department, by Railway Officials and by private individuals as to the best method of treating timber other than for sleepers, to effectively protect it from the attacks of white-ants or fungi or both. The answers given have necessarily had to be brief, and could not deal with the subject in detail. It is therefore thought that it would not be out of place to conclude this note by giving a short résumé as to how best to deal with such cases.

(*i*) TREATMENT OF CONSTRUCTIONAL TIMBER.

When considering the question of treating constructional timber, the following points have to be borne in mind : (*i*) the quantity and size of the timber which it is desired to treat, (*ii*) the position in which it is to be placed, (*iii*) the choice of antiseptic, and (*iv*) the cost. If the timber to be treated is for a large building, in other words, in considerable quantity, probably the erection of an *Open Tank* in which to treat the timber will be justified. Such a tank can be obtained for Rs. 300 to Rs. 500, according to its capacity, provided it is intended only for temporary work. The tank in which several thousand sleepers were treated at Jagadhri, and at Shahpur in the Central Provinces, cost under Rs. 200. The dimensions of the tank should be dependent on the size of the material to be treated. The tank should be sunk into the ground to within 6″ of the top, and if the oil is to be heated by direct fire and not by a steam coil, a 'Kutcha' masonry flue should be constructed underneath and along the length of the tank, with a sloping entrance at one end and a

short chimney at the other. It may be found convenient to erect a tripod over the tank, to which should be attached a set of pullies to facilitate the loading and unloading of the timber. On the tank being charged, the antiseptic solution should be heated to between 80°C. and 90°C. and then allowed to cool down. The time, during which the timber is allowed to remain in the solution, will depend on the amount of antiseptic it is proposed to introduce into the timber, the nature of the timber and the size of the pieces to be treated. It is not improbable that some of the timber to be treated will be found to be too long to go into the tank, such as beams and possibly some of the posts; for, to build a tank of sufficient size to take such timber would not be justified owing to the limited number of such pieces to be treated. Such timber can, however. be given a considerable amount of protection by placing it over the tank and ladling the hot solution over it for 10 or 15 minutes and by repeating this operation at least twice.

It has been mentioned that the position in which the timber is to be placed would affect the method of treatment to be adopted. In the case of timber which is destined for indoor work, the amount of protection which it is necessary to give is less than in cases when it will be exposed to atmospheric influences. Thus, in the case of Pine rafters for roofing, 2 lbs. or 3 lbs. per cubic foot might be sufficient, while 5 to 6 lbs. per cubic foot of the antiseptic would be necessary to effectively protect verandah posts. Wood coming in contact with the ground, on the other hand, should be treated to refusal in *Open Tanks.*

The choice of antiseptic, with which to treat timber destined for constructional work in dwelling houses, is a somewhat difficult problem. *Creosotes,* as used for sleeper work, cannot be used for internal work, as their odour is offensive, another reason being that creosoted wood cannot be painted. Good results have been obtained with *Solignum.* When first applied, it smells of creosote but this soon passes off. *Arsenic solutions,* such as *Atlas,* have been extensively used, especially in Assam, and the results obtained with this antiseptic are claimed to be quite satisfactory, the only objection to it being the poisonous nature of the solution. A very useful salt, with which to treat timber destined for internal construction, is *Chloride of Zinc,* used in a 2 per cent. solution; it is cheap, colourless and odourless and provided the timber is well saturated, affords considerable protection. The timber, after treatment, on being thoroughly dried, should be painted with any suitable pigment mixed with oil. The above remarks are based on the assumption that the timber is destined for internal work in dwelling houses; in the case of store-houses, barns, wooden bridges, canal weirs and structures of a similar nature, *creosote* alone or mixed with *Petroleum* oils is advocated, as the

objectionable smell of the *creosote* is, in such cases, generally of little or no consequence. The cost of treatment will depend on the depth of impregnation desired and the choice of antiseptic. *Creosote* and *Petroleum* oils, mixed in equal quantities, cost about 9 pies per lb.; *creosote* alone, which has to be imported from Europe, costs about 14 pies per lb. landed at Delhi or any other town in Northern India. *Solignum* costs Rs. 15 to Rs. 18 per 5-gallon drum, according to colour; *Jodelite* costs Rs. 2-11-0 per gallon; *Atlas* 'A' solution concentrated Rs. 16 in 5-gallon drums; *Green oil*, imported from England, comes to about 13 annas per gallon at Delhi; while *Chloride of Zinc* costs Rs. 20 per cwt. in Calcutta. The above are pre-war rates. From the above it will be seen that the patent solutions such as *Solignum* and *Jodelite* are expensive, but their nature allows them to be used for internal purposes in dwelling houses, which is not the case with the cheaper *creosote* oils of commerce. The salts are very cheap and may be considered fair preservatives, but as the timber after treatment probably requires to be painted, the total cost is considerably enhanced.

The above considerations have been based on the assumption that it has been decided to treat the timber by the *Open Tank* process but, if the amount of timber is insufficient to justify the erection of an *Open Tank* in which to treat it, the only alternative is to treat the timber by applying one or more coatings of the preservative in a hot state with a brush.

No mention has been made above of *Powellized* timber, as to erect a *Powell* plant to treat small quantities of timber only is probably out of the question. On the other hand, *Powellized* timber is very suitable for use in dwelling houses, as the treatment in no way adversely alters the appearance of the timber; moreover, such timber gives off no offensive odour and permits of being painted after treatment.

(*ii*) TREATMENT OF POSTS, FENCING POLES, TELEGRAPH POLES AND MINING PROPS.

It is a well-known fact that posts and poles of all descriptions, unless of the most durable timber, are especially liable to decay. The decay is most rapid in cases where the timber is placed in contact with the ground and in cases where sap-wood is present. Fencing and telegraph posts show the first signs of decay just above and below ground; in fact, unless a post is in an advanced stage of decay, the damage is generally confined to a 3 feet zone partly above and partly below ground. The bottoms of posts are often found to be quite sound, while the middle portion may have nearly disappeared. This is due to want of light

and air at the bottom of the post, conditions unfavourable to the action of fungoid growth. It necessarily follows that the greatest measure of protection must be given to the most vulnerable portions of the timber. In the case of fencing posts, which are generally not buried deep in the ground, it is not usually economically sound to differentiate between the lower and middle zones and, therefore, to facilitate matters, it is customary to treat the whole of the lower end of the post. In the case, however, of telegraph poles, which have to be buried deep in the ground, and especially when large numbers have to be treated and economy is a consideration, only about 2 feet above and below ground are treated. These remarks apply to cases in which the poles only contain heart-wood ; if, on the other hand, sap-wood is present the whole of the post should be treated, special attention being paid to the lower end.

In cases of mining props destined for erection in main galleries, in other words when the supports are of a more or less permanent nature, the posts should be treated throughout their length to refusal either in *Open Tanks* or preferably under pressure. The same remarks apply to timber to be placed in water, in such situations for instance, as weirs or sluice gates, which are subjected to the alternate action of water and a process of drying.

In the event of there being sufficient timber to justify the erection of an *Open Tank*, in which to treat the posts or telegraph poles, the best type of tank in which to treat the butts is a circular tank of from 6 feet to 8 feet diameter and of sufficient height to enable the ends of the post to be submerged in the antiseptic to the required depth.

Before leaving this subject, it should be mentioned that when considering the treatment of the ends of posts only, it is not intended to convey the idea that it is not better to treat the timber throughout : the idea of partial impregnation is only advocated from the point of view of economy. Moreover, it should be clearly understood that treatment under pressure is preferable to *Open Tank* treatment and that this treatment is again preferable to the *Brush* method of treatment, the selection of the process to be adopted depending on the quantity and quality of the timber to be dealt with and the purpose for which it is destined.

(2) General discussion.

It must be admitted that India is far behind most other civilized countries in the matter of treating timber and this may be attributed to the large supplies of timbers exceptionally durable in their natural state. These supplies are falling short of the ever-increasing demand,

especially in connection with sleeper woods, not that the present outturn of such timber has decreased, but that demand has forced up the prices to a point at which it is no longer profitable to convert more than a limited amount of such timbers into sleepers. The result is a shortage of sleeper woods and a corresponding tendency to look elsewhere for further supplies. This demand can, no doubt, be partially met by importing sleepers but, without a doubt, also by treating indigenous species of Indian timbers.

The Indian timbers which, it is thought, might prove suitable for sleepers, after treatment, are given in Chapter VI, Section 2. They are available from different provinces of India, the largest supplies being probably of *Dipterocarpus turbinatus* and *Terminalia Manii* from the Andamans; *Terminalia myriocarpa* and *Dipterocarpus pilosus* from Assam; *Dipterocarpus tuberculatus*, *D. alatus* and *Terminalia tomentosa* from Burma; *Abies Pindrow* and *Picea Morinda* from the Punjab and Kashmir; *Pinus longifolia* from the United Provinces and Punjab; and *Terminalia tomentosa* and *T. paniculata* from the West Coast of India. Without doubt, many other suitable species exist and localities could be named from which they, or the above timbers, could be obtained in considerable quantities, but the above list and localities may be considered as amongst the most important in British India.

The above remarks apply only to sleeper woods, but the treatment of constructional timber also deserves careful consideration. As far as the writer knows, with few exceptions, the Public Works Department, Canal Engineers, Railway Engineers, Builders and Private persons confine their efforts to protect constructional timber simply by painting, or varnishing the timber they employ in their works. This may or may not be sound business, it depends on the natural durability of the timber employed and the cost of replacing it at stated intervals. It is certain, however, that were treatment of timber more universally adopted for such purposes as we are considering, many Indian timbers at present not used for construction could be employed with equally good results, and at a cheaper initial cost, provided they were properly seasoned and treated before use. Moreover, the ever-increasing prices which it is necessary to pay for first class timber, and the shortage of supplies in some localities all point to the importance of giving careful consideration to this proposition which, if adopted, can but have the result of husbanding the timber resources of this country.

APPENDIX I.

List of publications and reports on the Antiseptic Treatment of Timber.

1. English publications.

1. Creosoted Wooden Poles.—*Timber Trades Journal*, 1907, Vol. LXII, page 570.

2. The Antiseptic Treatment of Timber,—by Sir Samuel Bagster Boulton, Bart. (Waterlow Bro. and Layton, Ltd., 24 and 25, Birehin Lane, E.C.)

3. Wood Preservation.—Paper read before the Central Electric Railway Association, by A. L. Kuehn, and reproduced in the *Timber Trades Journal*, August 5th, 1911, page 177.

4. The *Rueping Process* of Creosoting.— *Timber Trades Journal*, September 9th, 1911.

5. The Antiseptic Effect of *Creosote oil* and other oils used for preserving timber,—by John M. Wiess. (*Journal of the Society of Commercial Industry*, December 15th, 1911.)

2. Indian publications.

1. Memorandum on the establishment of a factory for impregnating Pine sleepers from the North-West Himalayas with metallic salts, by Dr. H. Warth, September 1878.

2. Memorandum on the supply of railway sleepers of the Himalayan Pines suitable for impregnation in India,—by Sir D. Brandis (*Inspector-General of Forests' Proceedings*, October 1878).

3. Impregnation of Himalayan Pine-wood for use as Railway sleepers.—*Government of India, Department of Revenue, Forests.—Proceedings* Nos. 8 to 10, May 1879.

4. Preservation of Timber.—*Indian Forester*, 1881, Vol. VI, page 142.

5. The Antiseptic Treatment of Timber.—*Indian Forester*, 1884, Vol. X, page 582.

6. The Preservation of Timber.—*Indian Forester*, 1886, Vol. XII, pages 127-137.

7. Methods of Preserving Timber in Japan.—*Indian Forester*, 1886, Vol. XII, page 527.

8. Preservation of Timber with *Carbolineum* oils.—*Indian Forester*, 1888, Vol. XIV, page 285.

9. Gardner's Process of Preserving Timber.—*Indian Forester*, 1889, Vol. XV, page 479.

10. Creosoting sleepers.—*Indian Forester*, 1891, Vol. XVII, page 217.

11. Creosoting timber.—*Indian Forester*, 1892, Vol. XVIII, page 238.

12. Pfister's process.—*Indian Forester*, 1892, Vol. XVIII, page 277.

13. Haskin's process.—*Indian Forester*, 1896, Vol. XXII, pages 32 and 33.

14. Haskin's process.—*Indian Forester*, 1898, Vol. XXIV, page 224.

2. *Indian publications*—contd.

15. Impregnation of Indian Timbers.—*Proceedings* Nos. 1 to 7, *of the Inspector-General of Forests,* July 1898.

16. Impregnation of Indian Timbers.—*Indian Forester,* 1898, Vol. XXIV, page 345.

17. Hasselmann's process.—*Indian Forester,* 1898, Vol. XXIV, page 439.

18. Report on Haskin's process.—*Indian Forester,* 1899, Vol. XXV, Appendix.

19. Preservation of timber by impregnation or the Haskin process.—*Proceedings* No. 8 *of the Inspector-General of Forests,* 1902.

20. Opinions of Local Governments and Railway Administrations on the proposal for establishing a central factory for the purpose of impregnating sleepers of inferior wood, or treating them by the Haskin's process.—*Public Works Department, Railway Stores,* IX. *Proceedings* of June 1902, Nos. 91—126.

21. Preservation of Bamboos from the attacks of the Bamboo beetle or "shot-borer."—by E. P. Stebbing, F.L.S., Calcutta, 1903.

22. Powell's process.—*Indian Forester,* 1903, Vol. XXIX, page 580.

23. Report of the Sub-Committee of the Board of Scientific Advice on Indian Timber sleepers.—"A" *Proceedings* Nos. 17-20 *of the Inspector-General of Forests,* 1905 (containing Mr. F. D. Couchman's note on the necessary quality of good railway sleepers).

24. Powell's process.—*Indian Forester,* 1906, Vol. XXXII, page 618.

25. Powell's process.—*Indian Forester,* 1907, Vol. XXXIII, page 281.

26. Powell's wood process for treating newly felled timber.—"A" *Proceedings* Nos. 66-67 *of the Inspector-General of Forests,* March 1907.

27. Utilization of Railway sleepers of inferior kinds of timber.—"A" *Proceedings* Nos. 5-7 *of the Inspector-General of Forests,* April 1907.

28. Utilization of inferior kinds of timber for railway sleepers.—*Proceedings of the Railway Board* (R. S.), September, 1907.

29. Powell's wood process for preserving timber.—*Railway Department, Proceedings* Nos. 156-165, June 1909.

30. Note on the Antiseptic Treatment of Timber in India, with special reference to Railway sleepers,—by R. S. Pearson, I.F.S., F.L.S. (*Indian Forest Records,* Vol. III, Part II, March 1912).

31. Sleeper Treatment. (*Indian Engineering,* July 13th, 1912, page 24.)

32. Factors in Wood Preservation. (*Indian Engineering,* April 12th, 1913.)

3. *American publications.*

1. The Decay of Timber and Methods of Preventing it.—*Bureau of Plant Industry, Bulletin* 14, 1902.

2. Seasoning of Timber.—*Forest Service Bulletin* 41, 25 cents., 1903.

3. Cross Tie Forms and Rail Fastenings with Special Reference to Treated Timbers—*Bulletin* 50, 15 cents., 1904.

4. Report on Condition of Treated Timbers Laid in Texas, February, 1902.—*Bulletin* 51, 10 cents., 1904.

5. Wood Preservation in the United States.—*Bulletin* 73, 10 cents., 1909.

6. The Preservative Treatment of Farm Timbers.—*Farmers' Bulletin* 387. 1910.

7. The Fractional Distillation of *Coal-Tar Creosote.*—*Forest Service Circular* 80. 1907.

3. American publications—contd.

8. Quantity and Character of Creosote in Well Preserved Timbers.—*Forest Service Circular* 98, 5 cents., 1907.

9. The Open Tank Method for the Treatment of Timber.—*Forest Service Circular* 101. 1907.

10. Brush and Tank Pole Treatments.—*Forest Service Circular* 104. 1907.

11 The Analysis and Grading of Creosotes.—*Forest Service Circular* 112. 1908.

12. The Preservative Treatment of Fence Posts.—*Forest Service Circular* 117. 1907.

13. Preservation of Piling Against Marine Wood Borers.—*Forest Service Circular* 128, 5 cents., 1908.

14. Experiments on the Strength of Treated Timber. (Second Edition.)—*Forest Service Circular* 39, 5 cents., 1908.

15. Holding Force of Railroad Spikes in Wooden Ties.—*Forest Service Circular* 46, 5 cents., 1906.

16. Wood Paving in the United States.—*Forest Service Circular* 141. 1908.

17. The Seasoning and Preservative Treatment of Hemlock and Tamarack Cross Ties.—*Forest Service Circular* 132, 5 cents., 1908.

18. The Estimation of Moisture in Creosoted Wood.—*Forest Service Circular* 134, 5 cents., 1908.

19. Primer of Wood Preservation.—*Forest Service Circular* 139. 1908.

20. Experiments with Railway Cross Ties.—*Forest Service Circular* 148, 5 cents., 1908.

21. Consumption of Wood Preservatives and Quantity of Wood Treated in 1910.—*Forest Service Circular* 186, 5 cents., 1911.

22. Preservative Treatment of Loblolly Pine Cross Arms.—*Forest Service Circular* 131, 5 cents., 1908.

23. Preservative Treatment of Poles.—*Forest Service Bulletin* 84, 15 cents., 1911.

24. Volatilization of Various Fractions of Creosote after their Injection into Wood.—*Forest Service Circular* 188, 5 cents., 1911.

25. Modification of Sulphonation Test for Creosote.—*Forest Service Circular* 191, 5 cents., 1911.

26. Prevention of Sap Satin in Lumber.—*Forest Service Circular* 192, 5 cents., 1912.

27. Progress Report on Wood Paving Experiments in Minneapolis.—*Forest Service Circular* 194, 5 cents., 1912.

28. Quantity and Quality of Creosote found in Two Treated Piles after Long Service.—*Forest Service Circular* 199, 1912.

29. The Preservation of Mine Timbers.—*Forest Service Bulletin* 107, 10 cents., 1912.

30. Commercial Creosotes.—*Forest Service Circular* 206, 10 cents., 1912.

31. The Absorption of Creosote by the Cell Walls of Wood.—*Forest Service Circular* 200, 5 cents., 1912.

32. Condition of Experimental Chestnut Poles in the Warren-Buffalo and Poughkeepsie-Newton Square Lines after Five and Eight years' Service.—*Forest Service Circular* 198, 5 cents., 1912.

33. Prolonging the life of Cross-Ties.—*Forest Service Circular* 118, 15 cents., 1913.

3. American publications—contd.

34. Service Tests of Ties.—*Forest Service Circular* 209, 5 cents., 1912.

35. Experiments in the Preservative Treatment of Red Oak and Hard Maple Cross Ties.—*Forest Service Bulletin* 126, 20 cents., 1913.

36. Relative Resistance of Various Conifers to Injection with Creosote.—*Department of Agriculture Bulletin* 101, 15 cents., 1914.

37. Tests of Wood Preservatives.—*Department of Agriculture Bulletin* 145, 10 cents., 1915.

38. The Toxicity to Fungi of Various Oils and Salts.—*Department of Agriculture Bulletin* 227, 10 cents., 1915.

39. The Preservation of Structural Timbers from Decay—by C. P. Winslow. (*Proc. Eng. Society of Eastern Pa.* Vol. 26, No. 9, pages 427—451, December 1910.)

40. Timber Preservation—by C. P. Winslow. (*Electric Traction Weekly*, 1911.)

41. Structure of Commercial Woods in Relation to the Injection of Preservatives,—by H. F. Weiss. (*Proc.* 8th *International Congress of Applied Chem.* Also *Jour. Ind. and Eng. Chem.* Vol. 5, No. 5. 1912 and May 1913.)

42. Some Tests to Determine the effect upon Absorption and Penetration of mixing Tar with Creosote,—by F. M. Bond. (*Proc. American Wood Preservers Association*, pages 216—274, 1913.)

43. The Transmission of Air Pressure in Cross-Ties,—by C. P. Winslow, (*Proc. American Wood Preservers Association*, pages 288—316. 1913.)

44. A Comparison of *Zinc Chloride* with *Coal-Tar Creosote* for Preserving Cross-Ties,—by H. F. Weiss. (*Proc. American Wood Preservers Association*, pages 71—83. 1913.)

45. Condition of Experimental Poles in the Augusta-Savannah and Helna-Meldrim Lines,—by C. H. Teesdale. (*Engineering News*, November 27th, 1913.)

46. Method of Determining the Amount of $ZnCl_2$ in Treated Wood,—by E. Bateman. (*Jour. Ind. and Eng. Chemistry*, January 1914).

47. The Effect of varying the Preliminary Air Pressure in treating Ties upon the Absorption and Penetration of Creosote,—by C. H. Teesdale. (*Proc. American Wood Preservers Association*, pages 323 to 351, 1914.)

48. Preliminary Work in Fire Proofing Wood,—by R. E. Prince. (*Proc. American Wood Preservers Assn.*, pages 158—172, 1914).

49. Air Seasoning of Timber,—by W. H. Kempfer. (Am. Ry. Eng. Assn. Bulletin 161, *Proceedings Railway Review*, part 2, pp. 163—232, November 1913-14 and 10th January 1914.)

50. Toxicity of various Wood Preservatives,—by C. J. Humphrey and R. M. Fleming. (*Jour. Ind. and Eng. Chemistry*, February 1914.)

51. The Protection of Ties from Mechanical Destruction,—by H. F. Weiss. (*Proc. American Wood Preservers Association*, pages 249—260, *Hardwood Record*, 1914.)

52. Experiments on the Bleeding and Swelling of Southern Yellow Pine Paving Blocks,—by C. H. Teesdale. (*Proc. American Society of Municipal Improvements*—pages 267—286, February 10-14, 1914.)

53. Efficiency of various Parts of *Coal Tar Creosote* against Marine Borers,—by C. H. Teesdale. (*Engineering Record*, 12th September 1914.)

54. How the Wood Preserving Industry can avoid possible injury resulting from the War,—By C. H. Teesdale. (*Engineering Record*, September 26-14, *Mfgrs. Record*, September 24-14. *So. Lumberman* Sept. 26-14, *Ry. Age. Gazette*, October 21-14.)

55. Decay in Wooden Bleachers,—by C. H. Teesdale. (*Engineering Record*, October 3-14, *American Lumberman*, October 3-14.)

3. American publications—concld.

56. Marine Wood Borers,—By C. H. Teesdale. (*Scientific American*, Supplement, December 5-14.)

57. Fire Proofing Wooden Shingles,—By H. F. Weiss. (*American Roofer*, December 1914.)

58. Records on the Life of Treated Timber in the United States,—By H. F. Weiss and C. H. Teesdale. (*Proc. American Wood Preservers Association*, pages 501—509, 1915.)

59. Bleeding and Swelling of Paving Blocks,—By C. H. Teesdale. (*Proc. American Wood Preservers Association*, pages 372—397, 1915.)

60. History of Treated Wood Block Pavements in the United States,—By C. H. Teesdale. (*Proc. American Wood Preservers Assn.*, pages 324—367, 1915.)

61. Temperature changes in Wood under treatment,—By G. M. Hunt. (*Proc. American Wood Preservers Assn.*, pages 85—100, 1915.)

62. Preservative Treatment of Timber,—By H. F. Weiss and C. H. Teesdale. (*International Engineering Congress*, 1915.)

63. The Preservation of Wood from Decay,—By C. H. Teesdale. (*The Armour Engineer*, March 1915.)

64. The Preservative Treatment of Wooden Silos,—By G. M. Hunt. (*American Lumberman*, 13th March 1915.)

65. Service Tests of Treated and Untreated Telephone Poles,—by C. H. Teesdale. (*Telephony*, 3rd April 1915.)

66. Experiments with Wood Paving Blocks (In Minneapolis),—by C. H. Teesdale. (*Municipal Journal*, 6th May 1915.)

67. Tests on the Inflammability of Untreated Wood and of Wood Treated with Fire Retarding Compounds,—By R. E. Prince. (*Proc. National Fire Protection Assn.*, pages 108—157, 1915.)

68. Rot in Stored Lumber,—By C. J. Humphrey. (*American Lumberman*, pages 32—33, 14th August 1915.)

69. Sterilization and Preservation of Line Poles by electricity. (*Forestry and Irrigation*: December 1907, Vol. XIII, page 651.)

70. Increasing the durability of Fence Posts, by F. W. Besley, State Forester, Maryland State, Board of Forestry, Baltimore, Md. 1912.

71. A Silicious Wood Preservative. (*Scientific American*, dated 3rd May 1913, Vol. CVIII, No. 18, page 401.)

72. The Preservation of Structural Timber,—By H. F. Weiss, Director, Forest Products Laboratory, U. S. Forest Service, 1915.

73. Some Factors Affecting the Application of Wood Preservation to Electric Railways,—By C. P. Winlow and C. H. Teesdale. (*Proc. American Electric Ry. Engineering Association*, 1915.)

74. Creosoted *Douglas Fir* Paving Blocks.—(*Association of Creosoting Companies of the Pacific Coast, Seattle, Washington*, October 1915.)

75. Creosoting *Douglas Fir* Bridge Stringers and Ties without Loss in Strength. (*Association of Creosoting Companies of Pacific Coast, Seattle, Washington*, February 1916.)

76. Wood Preserving, Vol. II, No. 4, October-December 1915.

4. French publications.

1. La Préservation des Bois contre la pourriture,—by Professor Henry, of the National Forest School, Nancy, France, 1909.

4. French publications—contd.

2. Éssai en Grand du Carbolineum Avenarius,—by Professor Henry, of the National Forest School, Nancy, France. (*Revue des Eaux et Forest*, No. 7, 1st April 1909.)

3. Préservation des Bois par des Procédés Simples,—by Professor E. Henry, Deputy Director, National Forest School, Nancy, France.

5. Australian publications.

1. Letters on the Powell Process from the Chief Engineer, West Australian Railways. (Antiseptic Ledger File of the Forest Economist, 1909-10.)

6. Austrian publications.

1. Letter on the Antiseptic Treatment of Timber,—by Hauptmann Basilieus Malenkovic of the Austrian Royal Engineers. (Antiseptic Ledger File of the Forest Economist, 1909-10.)

2. Letter on the subject of impregnation with *Fluoride* salts,—by Hauptmann Basilieus Malenkovic of the Austrian Royal Engineers. (Antiseptic Ledger File of the Forest Economist.)

3. Zur Holzkonservierung mit *Fluoriden*,—by Oberbaurat Robert, Nowotny, Vienna.

4. Uber Grübenholz Impragnierung mit 'Bellit,'—by Basilius Malenkovic, K. U. K., Hauptmann.

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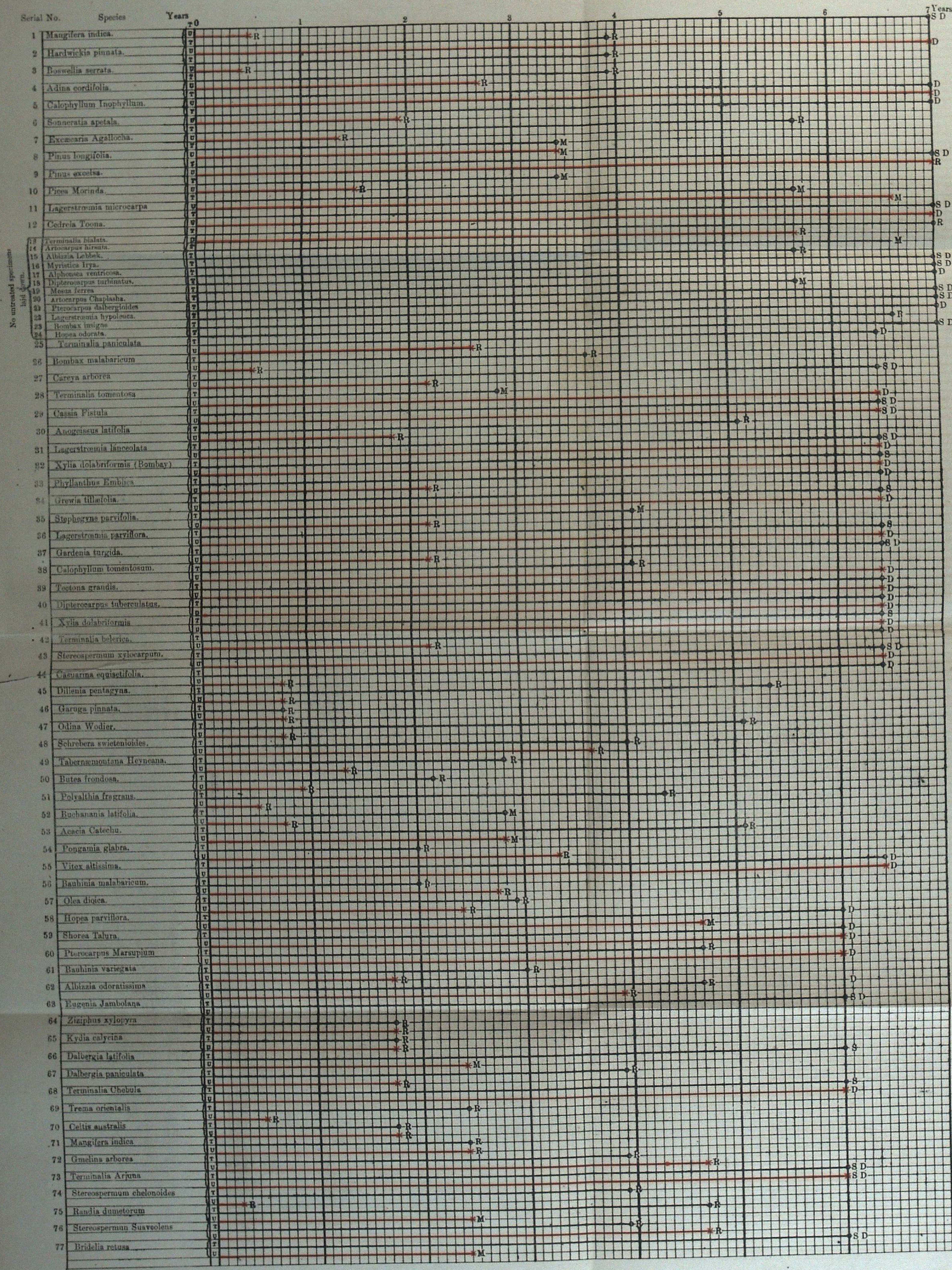
DIAGRAM I.

DURABILITY RECORD OF POWELLIZED SPECIMENS.



Black Lines denote Treated Specimens "T"
Red " " Untreated " "U"
"S" denotes sound
"SD" " slightly damaged
"D" " damaged but still serviceable
"R" " Rejected and unserviceable
"M" " Missing or Lost

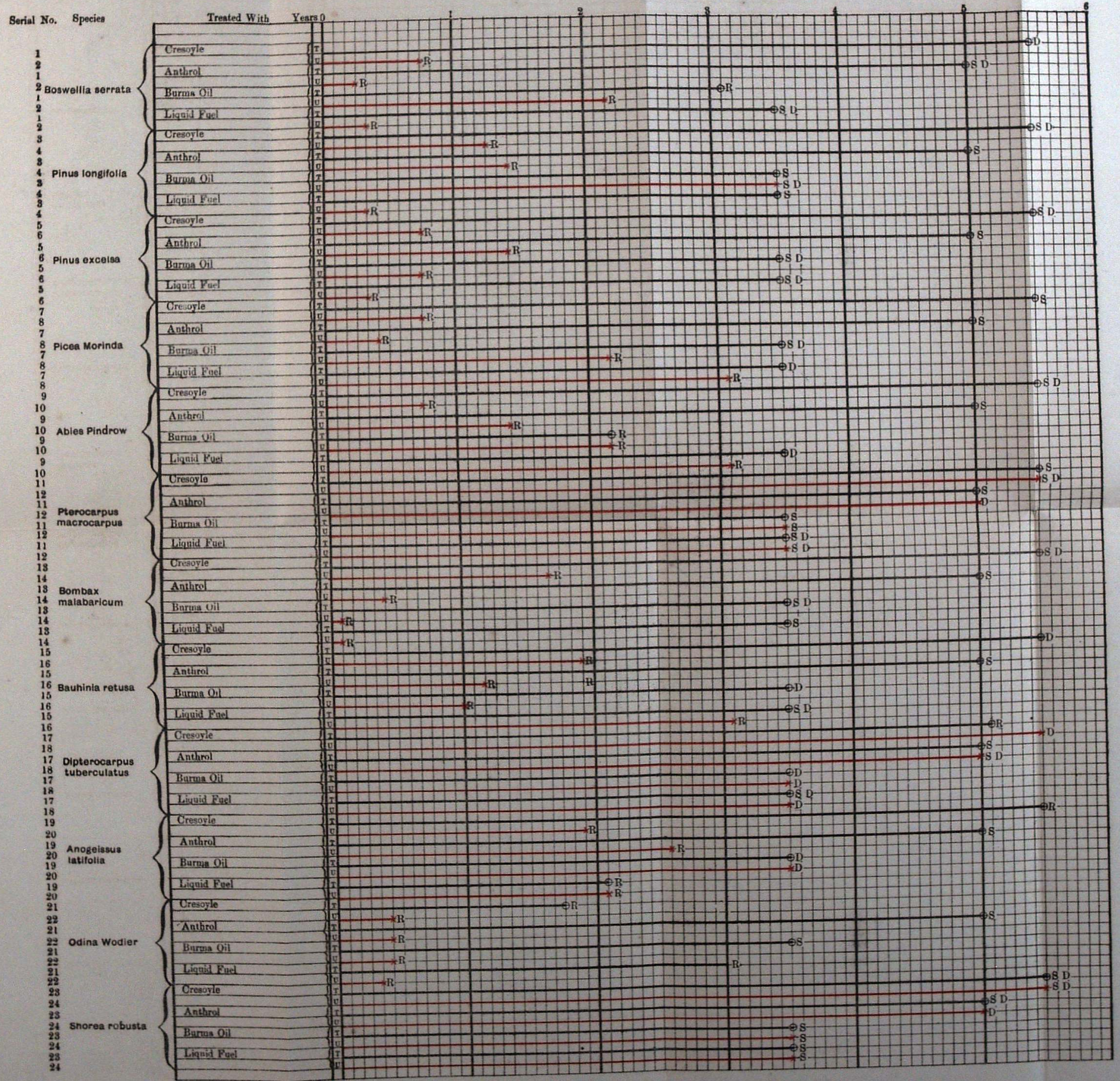
R. S. PEARSON,
Forest Economist.

Photo.-Mechl. and Litho. Dept., Thomason College, Roorkee.

June, 1917.—No. 147.

DIAGRAM III.

DURABILITY TESTS OF SPECIMENS TREATED WITH CRESOYLE, ANTHROL, BURMA OIL, AND LIQUID FUEL FROM BORNEO.



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Forest Economist.

June, 1917.—No. 147-2-1500.

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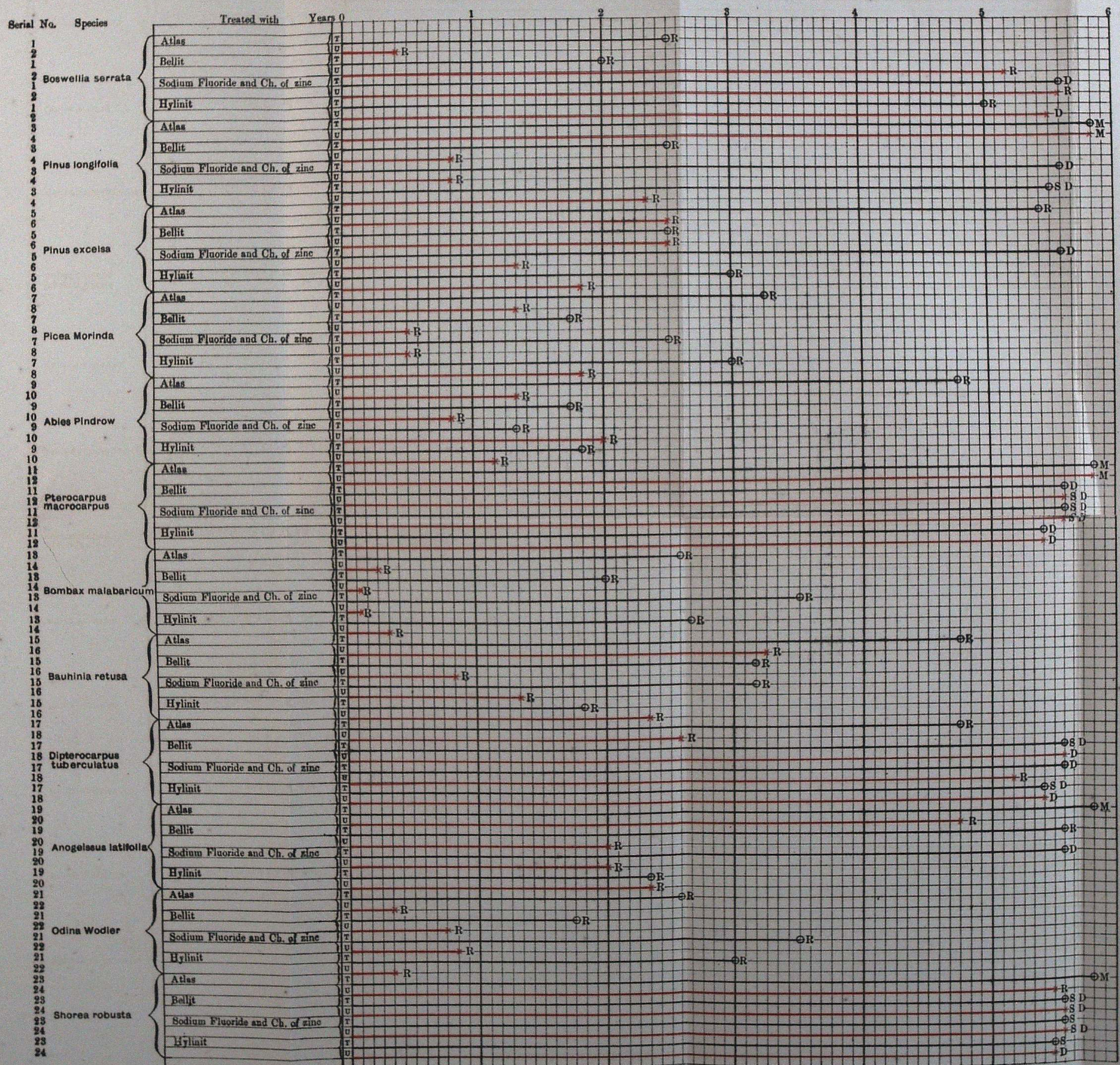
DIAGRAM IV.

DURABILITY TESTS OF SPECIMENS TREATED WITH ATLAS, BELLIT, SODIUM FLUORIDE AND CHLORIDE OF ZINC, AND HYLINIT.



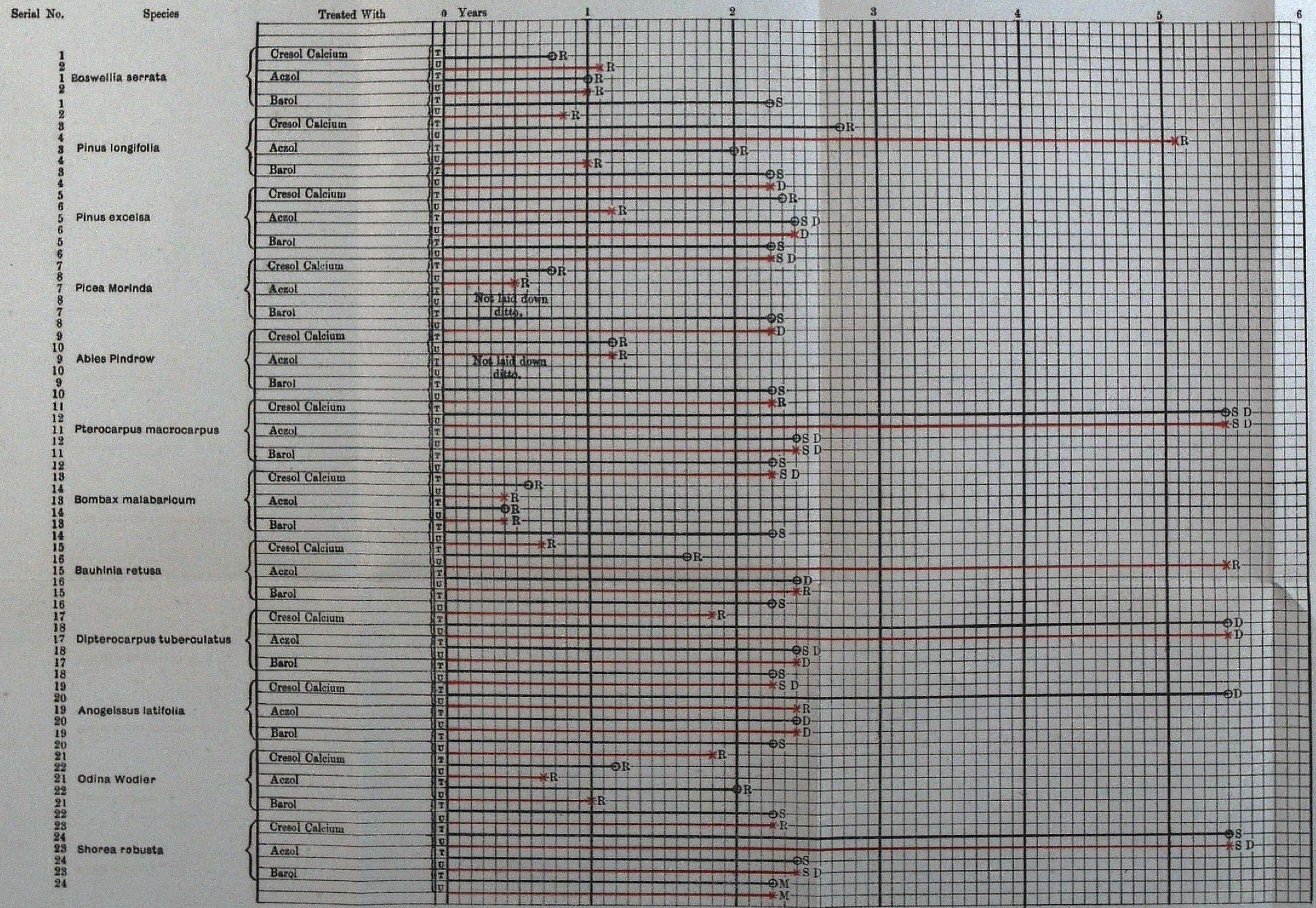
Black Lines denote Treated Specimens "T"
Red " " Untreated " "U"
"*S*" *denotes sound*
"*SD*" " *slightly damaged*
"*D*" " *damaged but still serviceable*
"*R*" " *rejected and unserviceable*
"*M*" " *missing*

R. S. PEARSON,
Forest Economist.

July, 1917—[illegible]

DIAGRAM VI.

DURABILITY TESTS OF SPECIMENS TREATED WITH CRESOL-CALCIUM, ACZOL, AND BAROL.



Black Lines denote Treated Specimens "*T*"
Red „ „ *Untreated* „ "*U*"
"*S*" *denotes sound*
"*SD*" „ *slightly damaged*
"*D*" „ *damaged but still serviceable*
"*R*" „ *rejected and unserviceable*
"*M*" „ *missing or lost*

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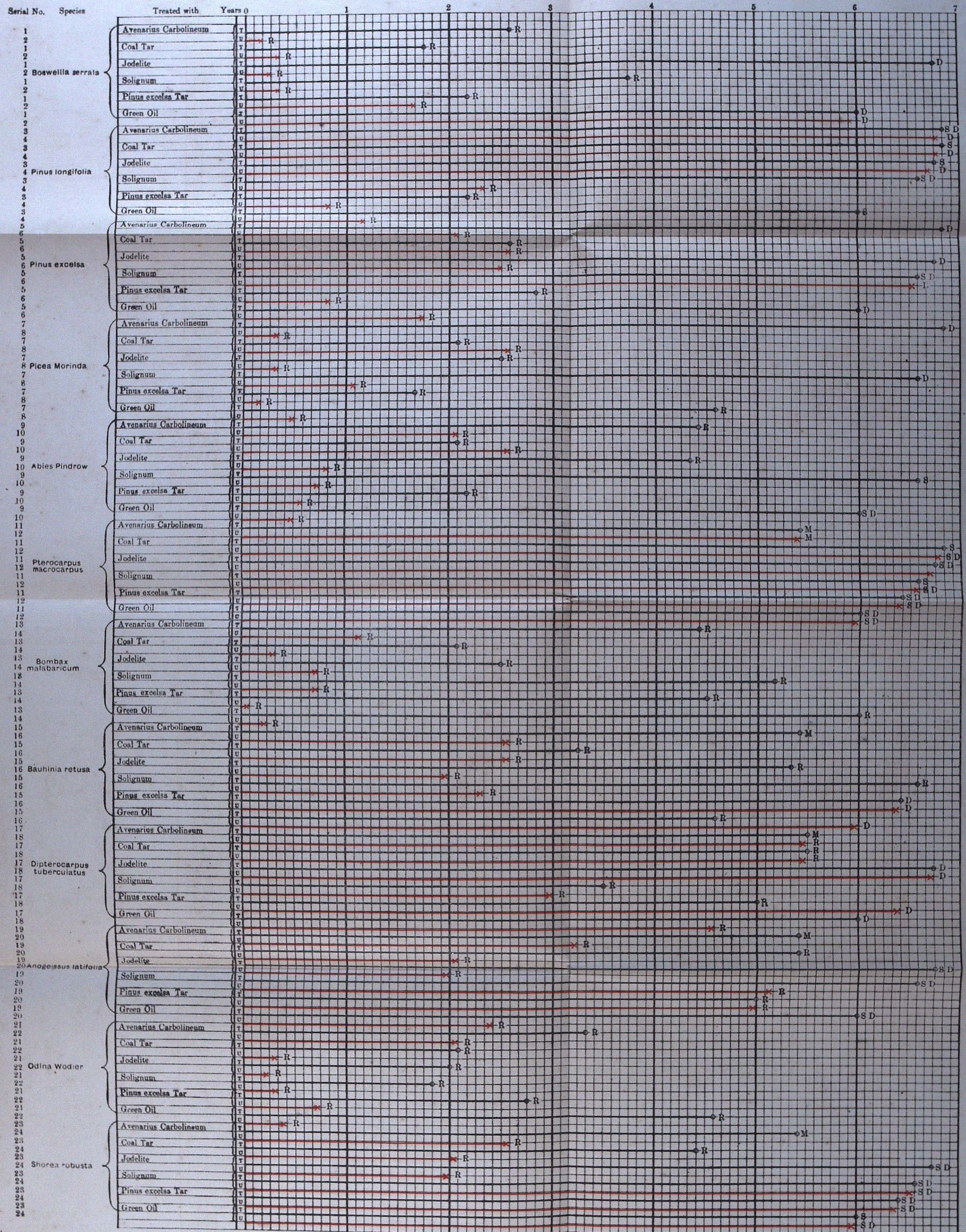
DIAGRAM II.

DURABILITY TESTS OF SPECIMENS TREATED WITH AVENARIUS CARBOLINEUM, COAL TAR, JODELITE, SOLIGNUM, PINUS EXCELSA TAR, AND GREEN OIL.



Black Lines denote Treated Specimens "T"
Red " " Untreated " "U"
"S" denotes sound
"SD" " slightly damaged
"D" " damaged but still serviceable
"R" " rejected and unserviceable
"M" " missing

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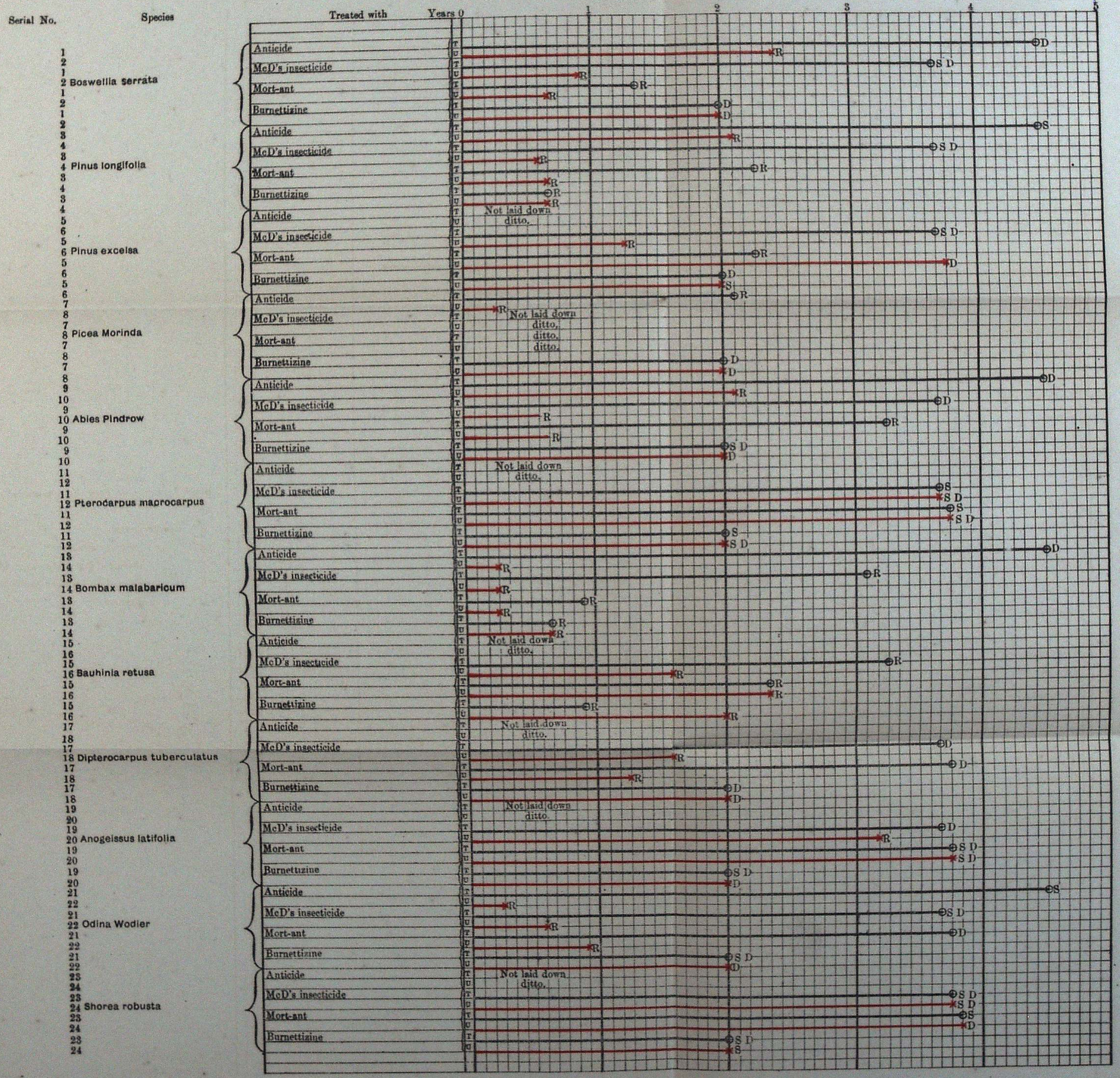
DIAGRAM V.

DURABILITY TESTS OF SPECIMENS TREATED WITH ANTICIDE, McDOUGALL'S INSECTICIDE, MORT-ANT AND BURNETTIZINE.



Black Lines denote Treated Specimens "T"
Red " " Untreated " "U"
"S" denotes sound
"SD" " Slightly damaged
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"M" " missing

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June, 1917.—No. 147-4-1500

Green oil and *Wax drippings*, mixed in equal proportions, by weight.	V	Ditto . .	7	10 minutes at 12 lbs. pressure.	10 minutes at 10 inches.	76°C.	15 minutes at 20 lbs. pressure.	*Nil*	11·2 lbs. per sleeper or 7·46 lbs. per cubic ft.	Ditto
	VI	*Dipterocarpus pilosus* or 'Hollong' green sleepers.	7	15 minutes at 20 lbs. pressure	15 minutes at 20 inches.	74°C.	1 hour at 100 lbs. pressure.	*Nil*	13·3 lbs. per sleeper or 8·86 lbs. per cubic ft.	Absolutely green sleepers containing 45·37 per cent. of moisture at time of testing.
	VII	*Dipterocarpus pilosus* or 'Hollong' air-dried sleepers.	(*i*) 5 } 7	Ditto .	15 minutes at 21 inches.	76°C.	Ditto	22·5 inches for ½ hour.	(*i*) 12·7 lbs. per sleeper or 8·46 lbs. per cubic ft.	The 5 dry and 2 green sleepers were treated together. The difference in this treatment to those, the results of which are recorded above, was in applying a final vacuum, the amount of oil recovered by doing so amounting to 42 lbs., or 6 lbs. per sleeper.
		Dipterocarpus pilosus or 'Hollong' quite green.	(*ii*) 2						(*ii*) 7·7 lbs. per sleeper or 5·14 lbs. per cubic ft.	
	VIII	*Terminalia myriocarpa* or 'Hollock' air-dried sleepers.	7	Ditto .	15 minutes at 20 inches.	75°C.	Ditto	*Nil*	5·3 lbs. per sleeper, or 3·54 lbs. per cubic ft.	Air-dried timber containing 29·27 per cent. of moisture at time of treatment.
Green oil and *Wax drippings*, mixed in equal proportions, by weight.	IX	Ditto . .	7	1 hour at 20 lbs. pressure.	50 minutes rising to 21 inches.	75°C.	2 hours at 150 lbs. pressure.	*Nil*	7·2 lbs. per sleeper or 4·8 lbs. per cubic ft.	Ditto
	X	Ditto . .	5	Ditto .	1 hour rising to 21 inches.	75°C.	2 hours at 200 lbs. pressure.	*Nil*	8·6 lbs. per sleeper or 5·74 lbs per cubic ft.	Ditto
	XI	*Bischofia javanica* or 'Uriam.'	2	10 minutes at 12 lbs. pressure.	10 minutes at 10 inches.	76°C.	15 minutes at 20 lbs. pressure.	*Nil*	4 lbs. per sleeper or 2·6 lbs. per cubic ft.	Partially air-dried timber.
	XII	Ditto . .	2	15 minutes at 20 lbs. pressure.	35 minutes at 20 inches.	72°C.	½ hour at 50 lbs. pressure.	*Nil*	3·25 lbs. per sleeper or 2·17 lbs. per cubic ft.	Ditto